

# Civil Engineering and Remote Sensing

Jean-Pierre Bardet

Chair, Sonny Astani Department of Civil and Environmental Engineering

Director, USC Center on Megacities

NASA Workshop  
February 2, 2010



# Acknowledgements

- Andrea Donellan, JPL
- Ellen Rathje, UT Austin
- Masanobu Shinozuka, UCI
- Ron Eguchi, ImageCat, Long Beach
- Masa Hamada, Waseda University, Japan
- Costas Synolakis, USC
- Costas Sioutas, USC
- American Society of Civil Engineers

- Grand Challenges in Engineering
- Civil Engineering and Infrastructure
- Megacities and urban Infrastructure
- Remote Sensing in Civil Engineering
- Future applications
- Recommendations

## Greatest Engineering Achievements OF THE 20<sup>TH</sup> CENTURY

◆ [About](#) ◆ [Timeline](#) ◆ [The Book](#)

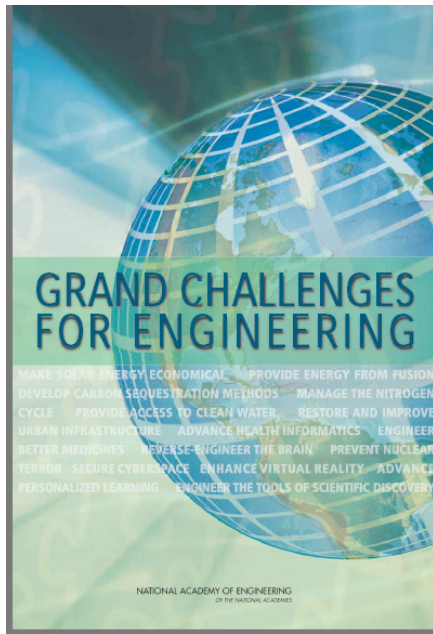
### Welcome!

How many of the 20th century's greatest engineering achievements will you use today? A car? Computer? Telephone? Explore our list of the top 20 achievements and learn how engineering shaped a century and changed the world.

- |  |  |
|--|--|
| 1. Electrification                     | 11. Highways                                 |
| 2. Automobile                          | 12. Spacecraft                               |
| 3. Airplane                            | 13. Internet                                 |
| 4. Water Supply and Distribution       | 14. Imaging                                  |
| 5. Electronics                         | 15. Household Appliances                     |
| 6. Radio and Television                | 16. Health Technologies                      |
| 7. Agricultural Mechanization          | 17. Petroleum and Petrochemical Technologies |
| 8. Computers                           | 18. Laser and Fiber Optics                   |
| 9. Telephone                           | 19. Nuclear Technologies                     |
| 10. Air Conditioning and Refrigeration | 20. High-performance Materials               |



# 14 Grand Challenges of NAE



Make solar energy economical



Provide energy from fusion



Develop carbon sequestration methods



Manage the nitrogen cycle



Provide access to clean water



Restore and improve urban infrastructure



Advance health informatics



Engineer better medicines



Reverse-engineer the brain



Prevent nuclear terror



Secure cyberspace



Enhance virtual reality



Advance personalized learning



Engineer the tools of scientific discovery

# National Academy of Engineering (NAE) Grand Challenges for Engineering



**Where does our water supply come from?**

**What is desalination?**

**What other technologies will provide clean water?**

**Provide**

.....  
**access to clean water**

When Samuel Taylor Coleridge wrote "water, water, everywhere, nor any drop to drink," he did not have the 21st century's global water situation in mind. But allowing for poetic license, he wasn't far from correct. Today, the availability of water for drinking and other uses is a critical problem in many areas of the world.



# NAE Grand Challenges for Engineering

**What is involved in maintaining infrastructure?**

**How can you improve transportation systems?**

**How do you build better infrastructure?**

**Restore and improve  
.....  
urban infrastructure**

In 2005, the American Society of Civil Engineers issued a report card, grading various categories of U.S. infrastructure.

The average grade was "D."



**How do you make solar energy more economical?**

**How do you store solar energy?**

## **Make solar energy economical**

**A**s a source of energy, nothing matches the sun. It out-powers anything that human technology could ever produce. Only a small fraction of the sun's power output strikes the Earth, but even that provides 10,000 times as much as all the commercial energy that humans use on the planet.



**How do you capture CO<sub>2</sub>?**

**How do you store CO<sub>2</sub>?**

## **Develop carbon ..... sequestration methods**

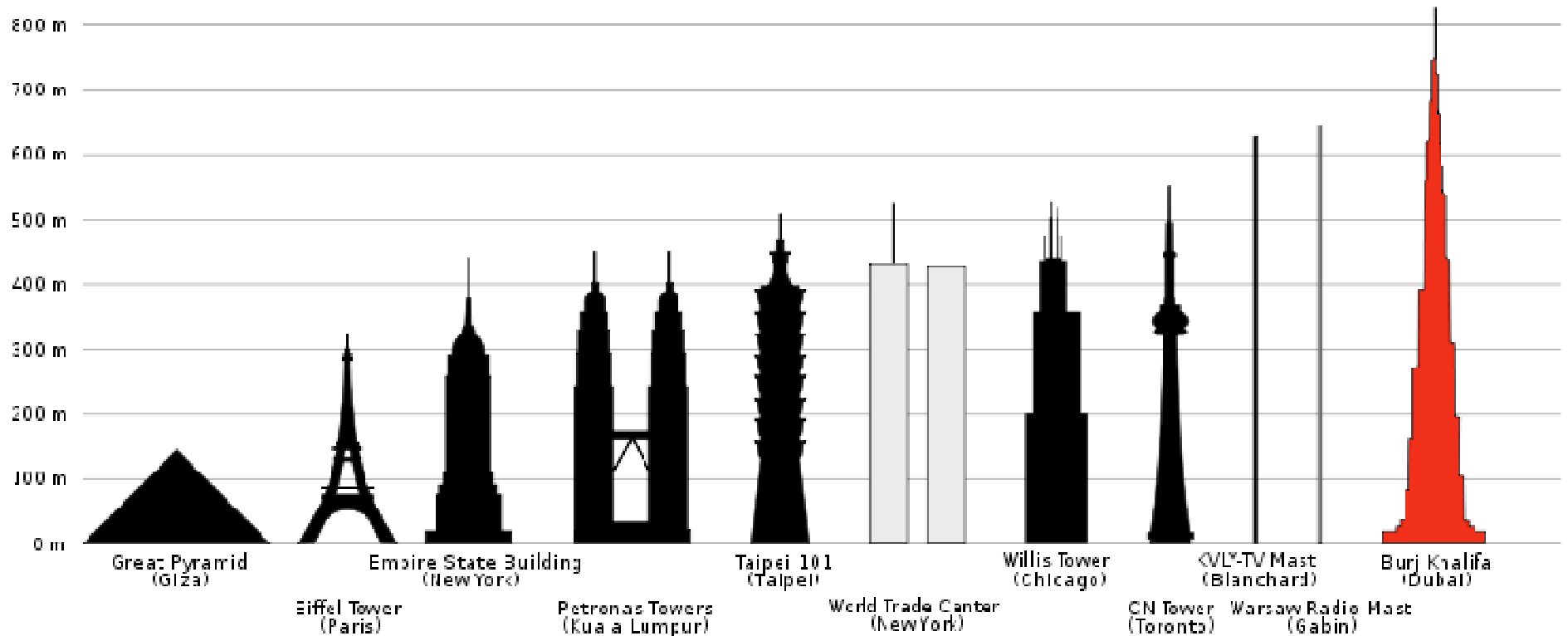
**T**he growth in emissions of carbon dioxide, implicated as a prime contributor to global warming, is a problem that can no longer be swept under the rug. But perhaps it can be buried deep underground or beneath the ocean.



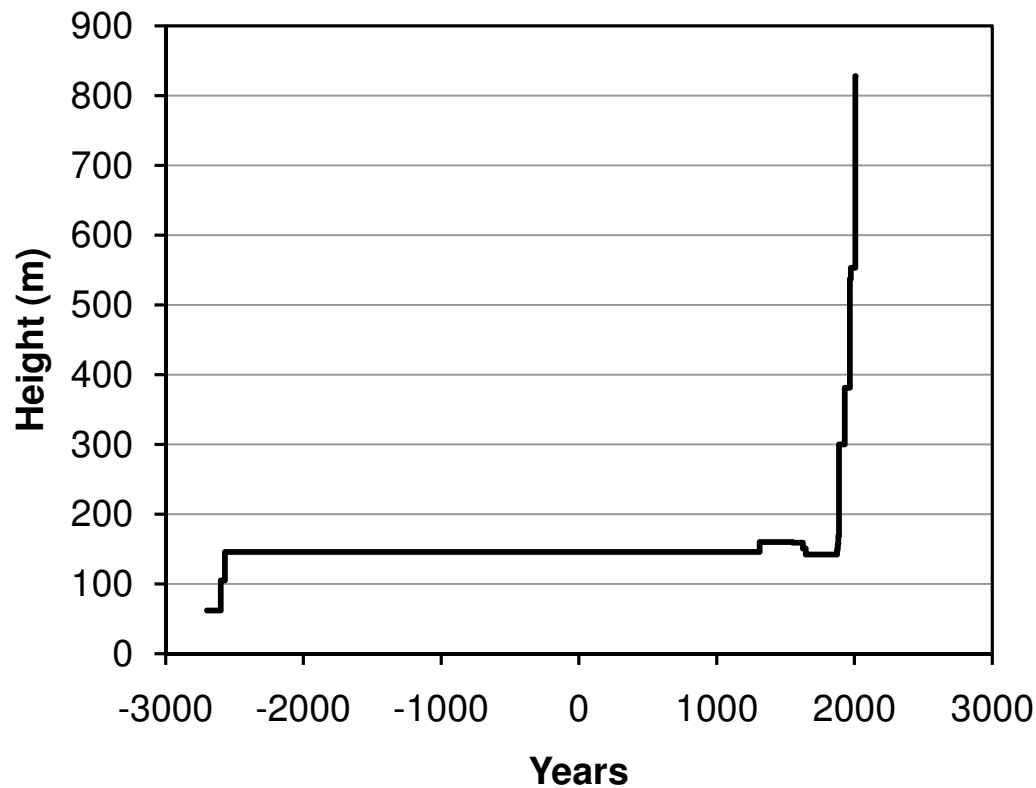
- Grand Challenges in Engineering
- **Civil Engineering and Infrastructure**
- Megacities and Urban Infrastructure
- Remote Sensing in Civil Engineering
- Future Applications
- Recommendations

- Civil engineering is the second oldest engineering discipline after military engineering.
- The term “civil engineering” was coined to differentiate from military engineering.
- Civil engineers design and build not only buildings and bridges but also infrastructures.

# Tallest Structures



# History of Tallest Structures



	Name and Location	Height (meters)
2700 BC	<a href="#">Pyramid of Djoser</a> , Egypt	62
2600 BC	<a href="#">Red Pyramid of Sneferu</a> , Egypt	105
2570 BC	<a href="#">Great Pyramid of Giza</a> in Egypt	146
1311	<a href="#">Lincoln Cathedral</a> in England	160
1549	<a href="#">St. Olaf's Church</a> in <a href="#">Tallinn</a> , Estonia	159
1625	<a href="#">St. Mary's Church</a> in <a href="#">Stralsund</a> , Germany	151
1647	<a href="#">Strasbourg Cathedral</a> in France	142
1874	<a href="#">St. Nikolai</a> in Hamburg, Germany	147
1876	<a href="#">Cathédrale Notre Dame</a> in Rouen, France	151
1880	<a href="#">Cologne Cathedral</a> in Germany	157
1884	<a href="#">Washington Monument</a> in Washington D.C., United States	169
1889	<a href="#">Eiffel Tower</a> in Paris, France	300
1930	<a href="#">Chrysler Building</a> in New York, United States	319
1931	<a href="#">Empire State Building</a> in New York, United States	381
1967	<a href="#">Ostankino Tower</a> in Moscow, Russia	537
1975	<a href="#">CN Tower</a> in Toronto, Canada	553
2007	<a href="#">Burj Khalifa</a> in Dubai, United Arab Emirates	828

# Tallest Structures

- CN Tower
- Location: Toronto
- Height: 553 m
- Built in: 1976

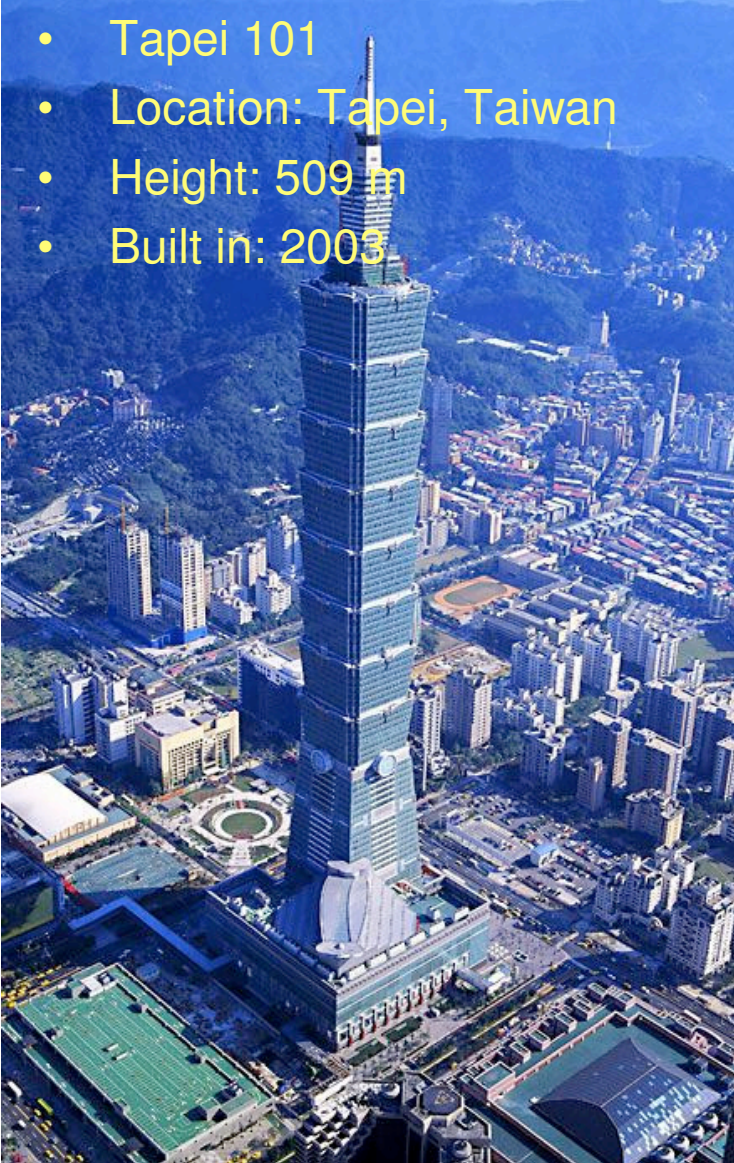


- Willis Tower
- Location: Chicago
- Height: 527 m
- Built in: 1974



# Tallest Structures

- Taipei 101
- Location: Taipei, Taiwan
- Height: 509 m
- Built in: 2003



- Petronas Towers
- Location: Kuala Lumpur
- Height: 452 m
- Built in: 1998



# Tallest Structures

- Warsaw Radio Mast
- Location: Warsaw, Poland
- Height: 646 m
- Built in: 1974
- Collapsed in: 1991



- Burj Khalifa
- Location: Dubai
- Height: 828 m
- Built in: 2007



# Longest Bridges



- Pontchartrain Causeway
- Location: Louisiana
- Length: 38,442 m
- Built in: 1956

- Donghai Bridge
- Location: People's Republic of China
- Length: 32,500 m
- Built in: 2005



# Hangzhou Bay Bridge

Carries	6 lanes of expressway
Crosses	<u>Hangzhou Bay</u>
Locale	<u>Jiaxing</u> / <u>Cixi</u> <u>City People's</u> <u>Republic of China</u>
Total length	35.673 km (22 mi)
Longest span	448 m (1,470 ft)
Opened	2008



# Longest Span Bridges



**No. 1 Akashi-Kaikyō Bridge**

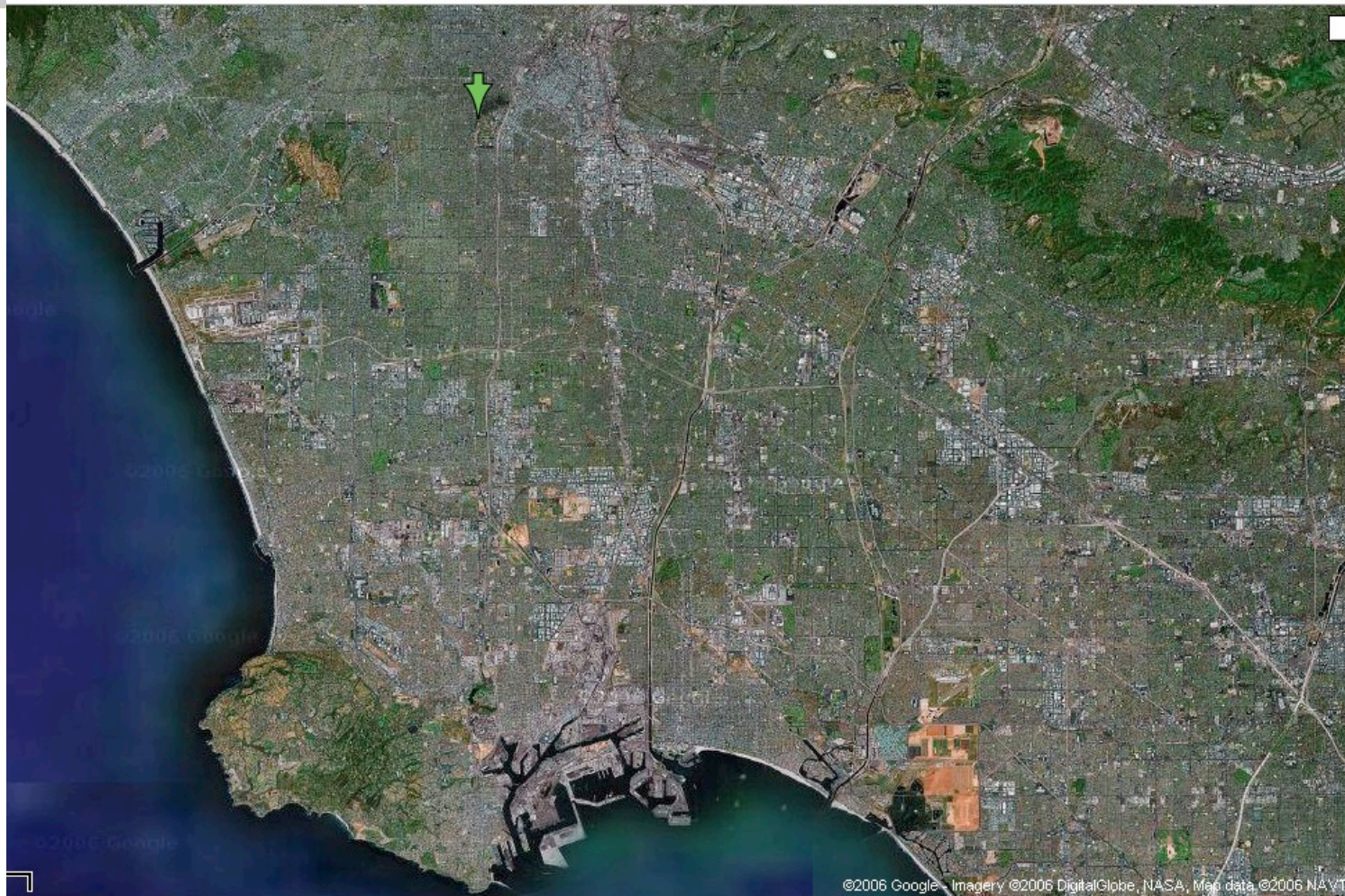
Main Span (m)	1,991
Year Opened	1998

**No. 9 Golden Gate Bridge  
(No. 1 from 1937 until 1964)**

Main Span (m)	1,280
Year Opened	1937



But there are more than buildings  
and bridges... Infrastructures



# USC Viterbi

School of Engineering



## 2009 REPORT CARD \*\*\*\*\* for \*\*\*\*\* america's INFRASTRUCTURE

**A** = Exceptional  
**B** = Good  
**C** = Mediocre  
**D** = Poor  
**F** = Failing

Each category was evaluated on the basis of condition and performance, capacity vs. need, and funding vs. need.

Aviation	<b>D</b>
Bridges	<b>C</b>
Dams	<b>D</b>
Drinking Water	<b>D-</b>
Energy	<b>D+</b>
Hazardous Waste	<b>D</b>
Inland Waterways	<b>D-</b>
Levees	<b>D-</b>
Public Parks and Recreation	<b>C-</b>
Rail	<b>C-</b>
Roads	<b>D-</b>
Schools	<b>D</b>
Solid Waste	<b>C+</b>
Transit	<b>D</b>
Wastewater	<b>D-</b>

AMERICA'S  
INFRASTRUCTURE G.P.A.

**D**


ESTIMATED 5 YEAR  
INVESTMENT NEED


**\$2.2**  
TRILLION

<http://www.infrastructurereportcard.org/report-cards>




- ASCE Report Card





[★ HOME](#)
[★ REPORT CARDS](#)
[★ STATES](#)
[★ CATEGORIES](#)
[★ SOLUTIONS](#)
[★ TAKE ACTION](#)
[★ NEWSROOM](#)





### 2009 Grades

Aviation	D
Bridges	C
Dams	D
Drinking Water	D-
Energy	D+
Hazardous Waste	D
Inland Waterways	D-
Levees	D-
Public Parks and Recreation	C-
Rail	C-
Roads	D-
Schools	D
Solid Waste	C+
Transit	D
Wastewater	D-

America's Infrastructure GPA: **D**

Estimated 5 Year Investment Need: **\$2.2 Trillion**

### It's Your State

What's the state of your State's infrastructure? Find out now

### Key Solutions

ASCE offers five ambitious ways to raise the grades. Read them.

### Get Involved

Join Our Facebook Group: "Save America's Infrastructure"

ASCE Member? Be a Key Contact

Meet the New Kid on the Blogroll

ASCE and Building America's Future Call for National Infrastructure Bank

ARRA's Doing What It's Supposed to Do

[more](#)

### Take Our Poll

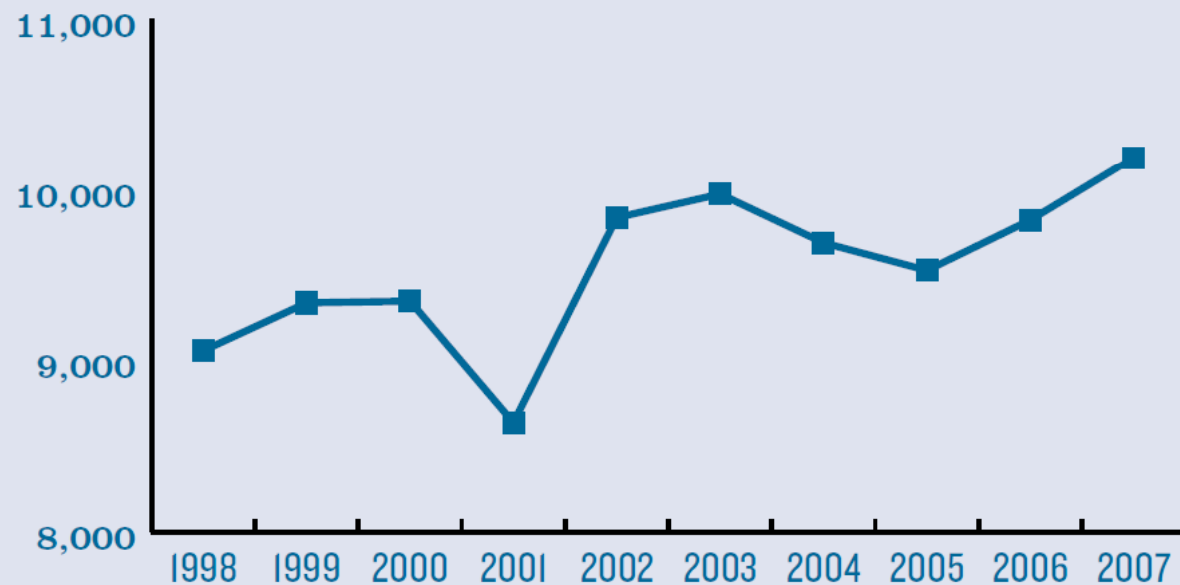
Five categories received D-. Which is the most urgent?:

- ☐ Drinking Water
- ☐ Inland Waterways
- ☐ Levees
- ☐ Roads
- ☐ Wastewater

COPYRIGHT ©2009 | [PRIVACY](#) | [TERMS AND CONDITIONS](#) | [CONTACT US](#)

# ASCE Report Card: D Dams

**FIGURE 1.1** ★ Number of High Hazard Dams in the United States



**SOURCE** Association of State Dam Safety Officials

**TABLE 4.1** ★ Damages from Flooding in Levee-Related Areas

LOCATION/YEAR	DAMAGES IN DOLLARS
Midwest 1993	\$272,872,070
North Dakota/Minnesota 1997	\$152,039,604
Hurricane Katrina 2005	\$16,467,524,782
Midwest 2008	\$583,596,400
<b>SOURCE</b> National Committee on Levee Safety	

# ASCE Report Card: D- Drinking Water

**TABLE 2.2** ★ Water Usage: 1950 and 2000

	1950	2000	PERCENT CHANGE
Population (Millions)	93.4	242	159%
Usage (Billions of Gallons per Day)	14	43	207%
Per Capita Usage (Gallons per Person per Day)	149	179	20%
<b>SOURCE</b> US EPA Clean Water and Drinking Water Infrastructure Gap Analysis Report, September 2002			

## Drinking Water – National D-



Leaking pipes lose an estimated 7 billion gallons  
of clean drinking water a day

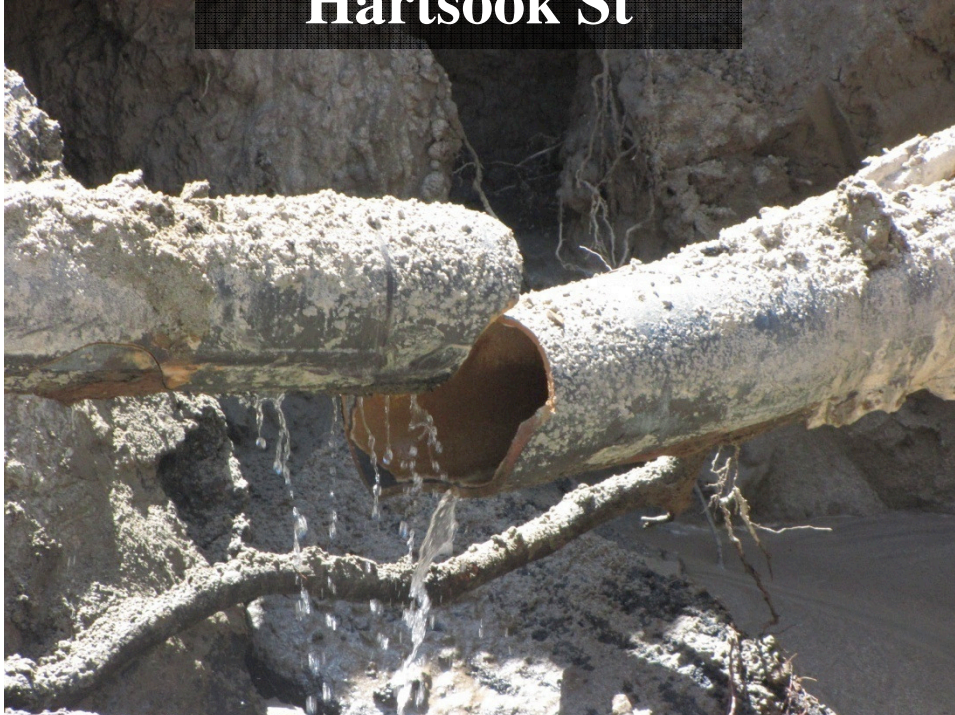
- Total value of water supply networks is estimated at \$4.8 billion per million population
- 26% of US water systems are unlined cast iron and steel in poor condition with a replacement value of \$348 billion
- In the US, 2 million miles of pipeline, mostly buried and hard to access
  - 250,000 to 300,000 “breaks” per year
- USGS Reports 6 billion gal/year are “losses or public use”- enough to supply the 10 largest US cities



Hartsook St



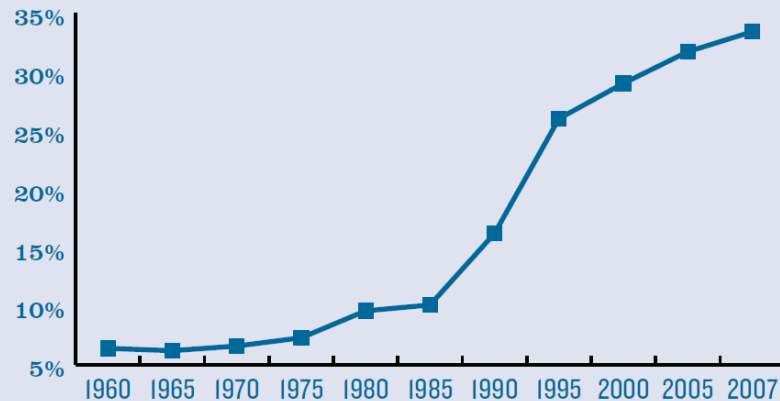
Corbin &  
Kittridge



Would you drink water from those pipes?



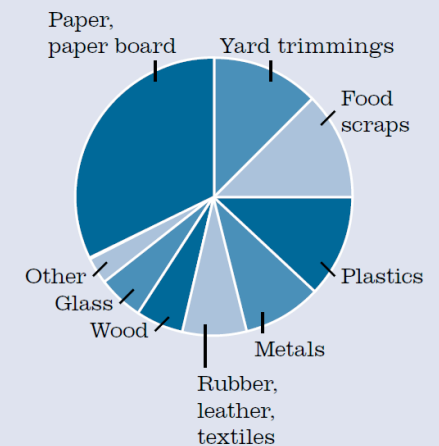
**FIGURE 5.1** ★ Percent of Municipal Solid Waste that is Recycled:  
1960–2007



**SOURCE** EPA Facts and Figures about Municipal Solid Waste, 2008

**FIGURE 5.2** ★ Components of Municipal Solid Waste  
(254 million tons generated in 2007)

	% OF MSW
Paper, paper board	32.7
Yard trimmings	12.8
Food scraps	12.5
Plastics	12.1
Metals	9.2
Rubber, leather, textiles	7.6
Wood	5.8
Glass	5.3
Other	3.2



**SOURCE** EPA Facts and Figures About Municipal Solid Waste, 2008

# ASCE Report Card: C Bridges

**TABLE 8.1** ★ U.S. Bridge Statistics

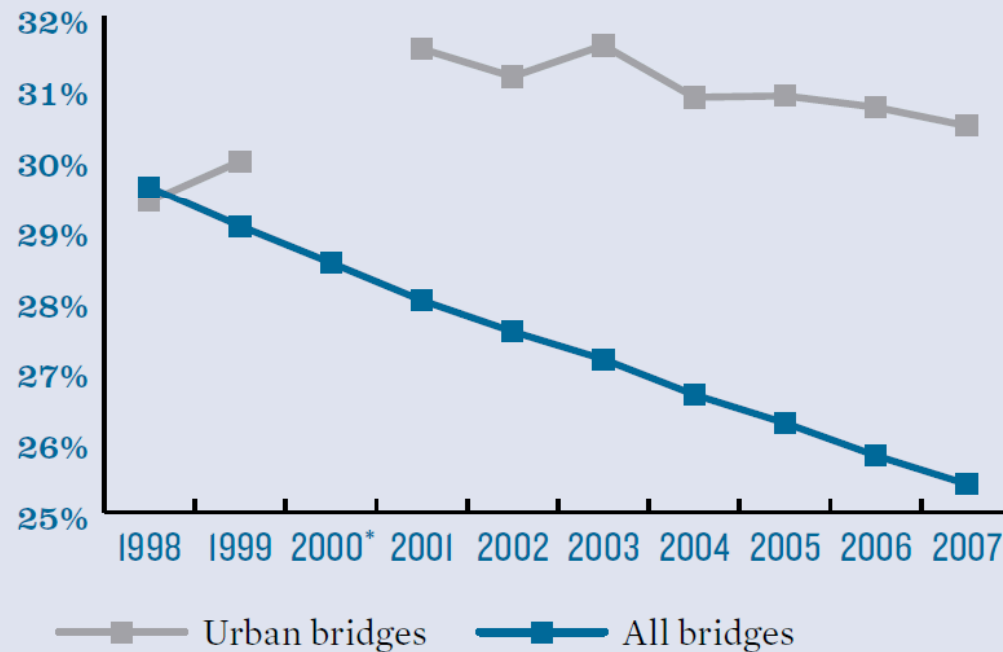
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<b>All Bridges</b>	<b>582,976</b>	<b>585,542</b>	<b>589,674</b>	<b>589,685</b>	<b>590,887</b>	<b>591,940</b>	<b>593,813</b>	<b>595,363</b>	<b>597,340</b>	<b>599,766</b>
Urban	128,312	130,339	133,384	133,401	135,339	135,415	137,598	142,408	146,041	151,171
Rural	454,664	455,203	456,290	456,284	455,548	456,525	456,215	452,955	451,299	448,595
<b>Structurally Deficient Bridges, Total</b>	<b>93,072</b>	<b>88,150</b>	<b>86,692</b>	<b>83,595</b>	<b>81,261</b>	<b>79,775</b>	<b>77,752</b>	<b>75,923</b>	<b>73,784</b>	<b>72,520</b>
Urban	14,073	12,967	NA	12,705	12,503	12,316	12,175	12,600	12,585	12,951
Rural	78,999	75,183	NA	70,890	68,758	67,459	65,577	63,323	61,199	59,569
<b>Functionally Obsolete Bridges, Total</b>	<b>79,500</b>	<b>81,900</b>	<b>81,510</b>	<b>81,439</b>	<b>81,537</b>	<b>80,990</b>	<b>80,567</b>	<b>80,412</b>	<b>80,317</b>	<b>79,804</b>
Urban	27,588	26,095	29,398	29,383	29,675	29,886	30,298	31,391	32,292	33,139
Rural	51,912	52,835	52,112	52,056	51,862	51,104	50,269	49,021	48,025	46,665

NA = Not Available

**SOURCE** *Transportation Statistics Annual Report*, U.S. Department of Transportation, Bureau of Transportation Statistics, 2008

# ASCE Report Card: C Bridges

**FIGURE 8.1** ★ Percent of Deficient Bridges in the United States



\* 2000 data not available

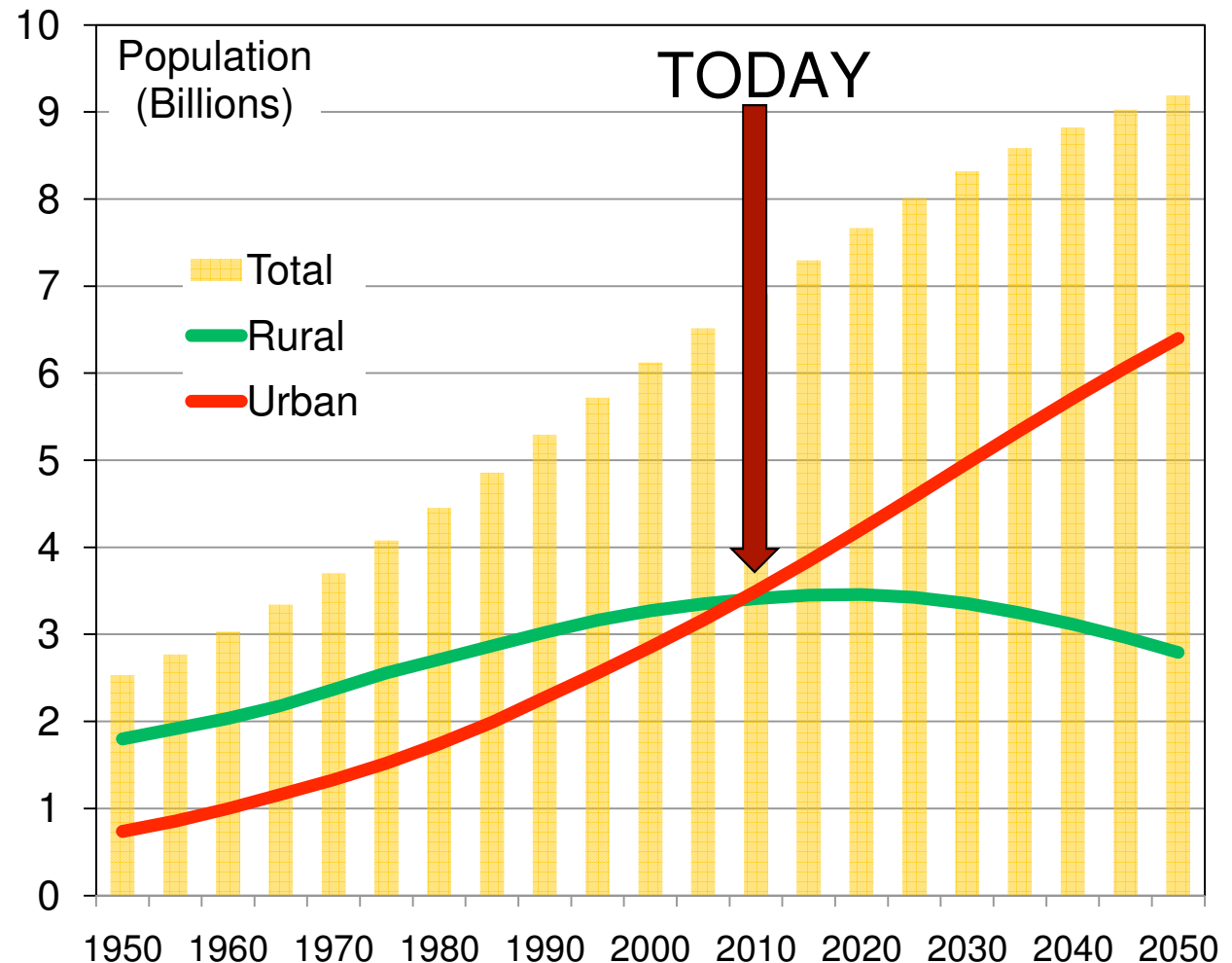
**SOURCE** *State Transportation Statistics: 2007*, U.S. Department of Transportation, Bureau of Transportation Statistics, 2008

- Grand Challenges in Engineering
- Civil Engineering and Infrastructure
- **Megacities and Urban Infrastructure**
- Remote Sensing in Civil Engineering
- Future Applications
- Recommendations

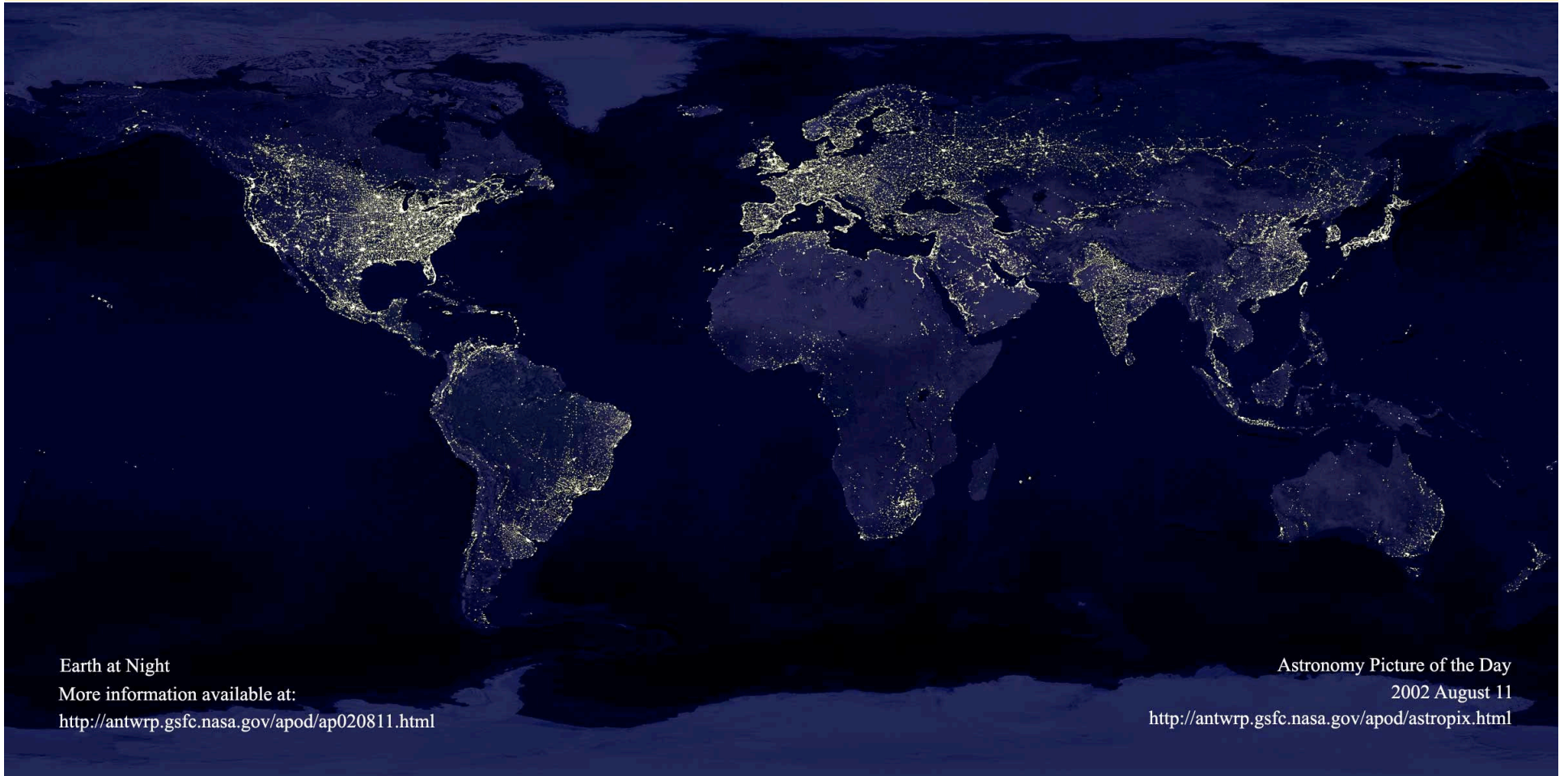
# World Urbanization

By 2008, for the first time in history, half of the world's population will live in urban areas.

Source:  
United Nations, 2005



# Megacities From Space



Earth at Night

More information available at:

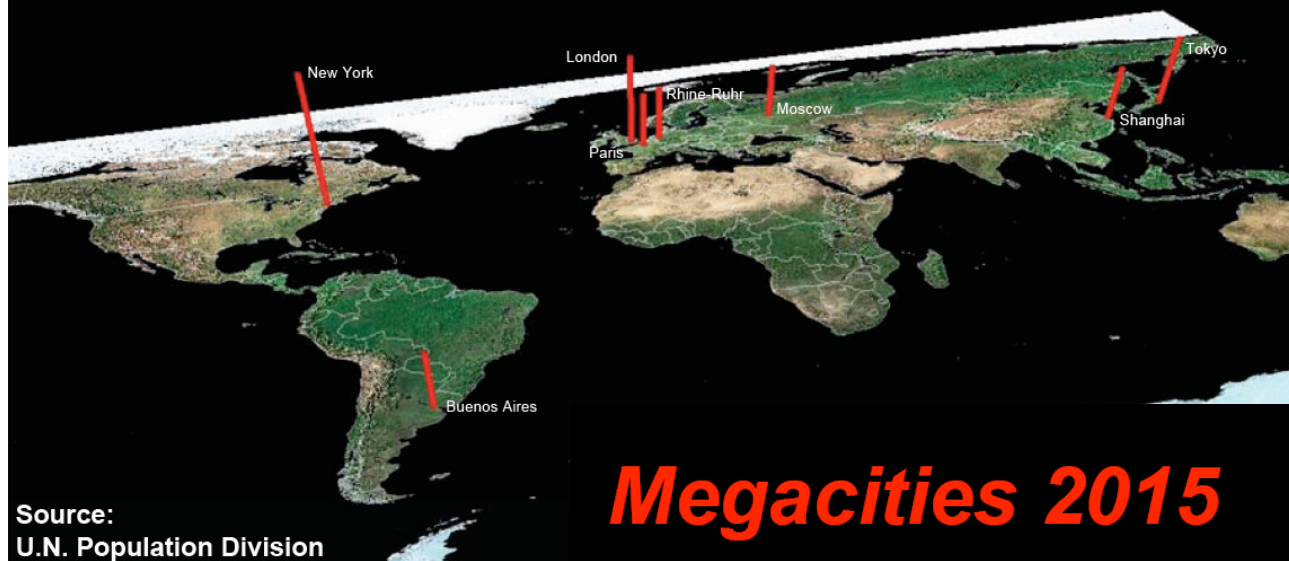
<http://antwrp.gsfc.nasa.gov/apod/ap020811.html>

Astronomy Picture of the Day

2002 August 11

<http://antwrp.gsfc.nasa.gov/apod/astropix.html>

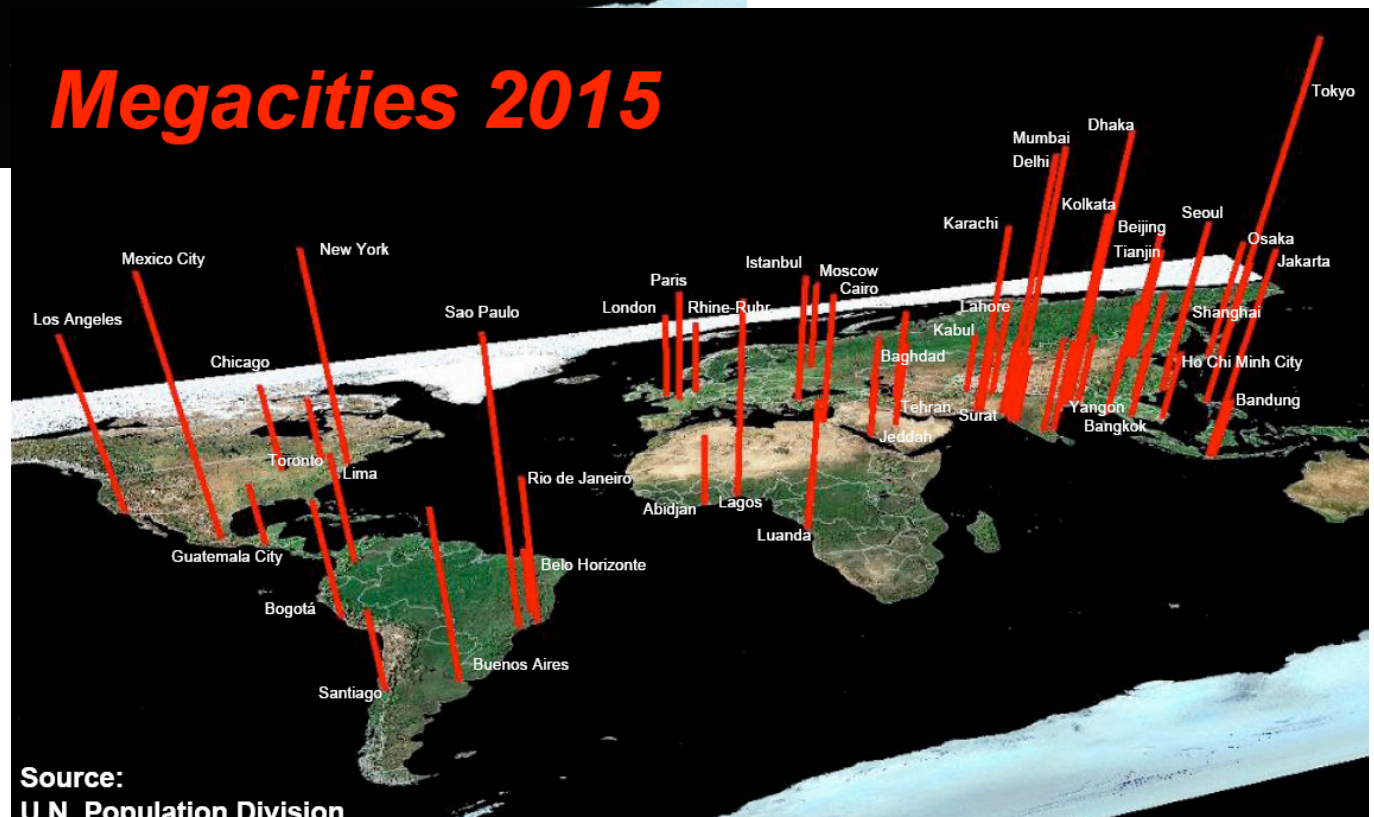
# Megacities 1950



Source:  
U.N. Population Division

# Megacities

# Megacities 2015



Source:  
U.N. Population Division

# Characteristics of Megacities

- Have high concentration of people, values and infrastructure
- Have high interconnectivity within region/country/continent / world
  - Interdependent flow of goods, finance and information
  - global cities: gateways of regional markets
- Have infrastructures that are enormous, aging, fragmented, complicated and interdependent


- Grand Challenges in Engineering
- Civil Engineering and Infrastructure
- Megacities and Urban Infrastructure
- **Remote Sensing in Civil Engineering**
- Future Applications
- Recommendations

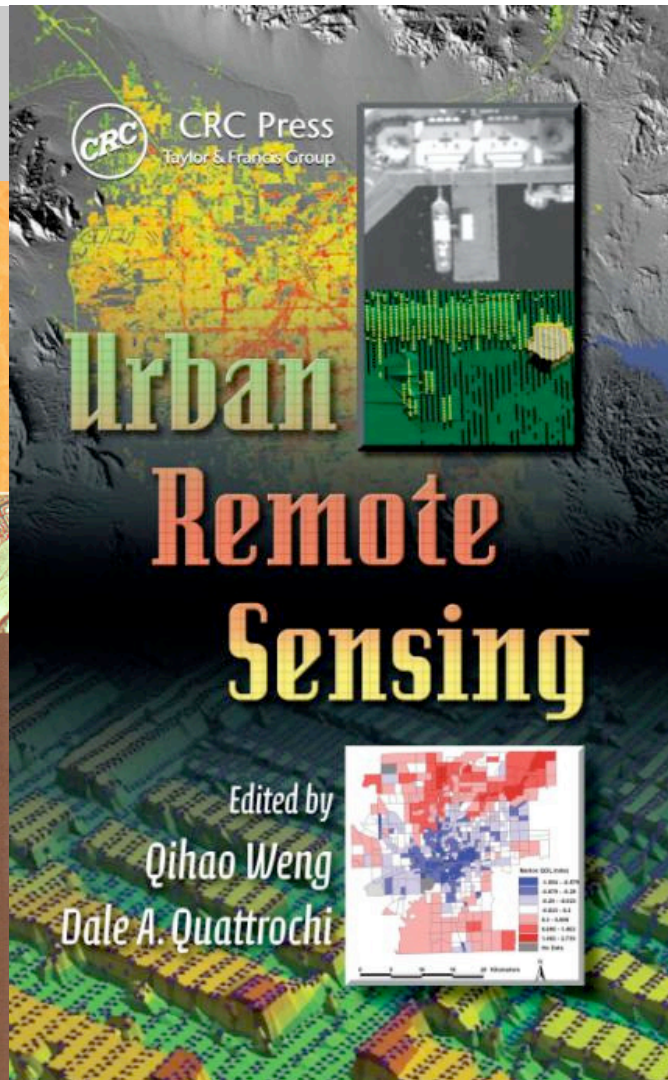
# USC Viterbi

School of Engineering

M. Netzband  
W. L. Stefanov  
C. Redman  
(Eds.)

## Applied Remote Sensing for Urban Planning, Governance and Sustainability

 Springer



SECOND EDITION

## Remote Sensing of the Environment

An Earth Resource Perspective



John R. Jensen

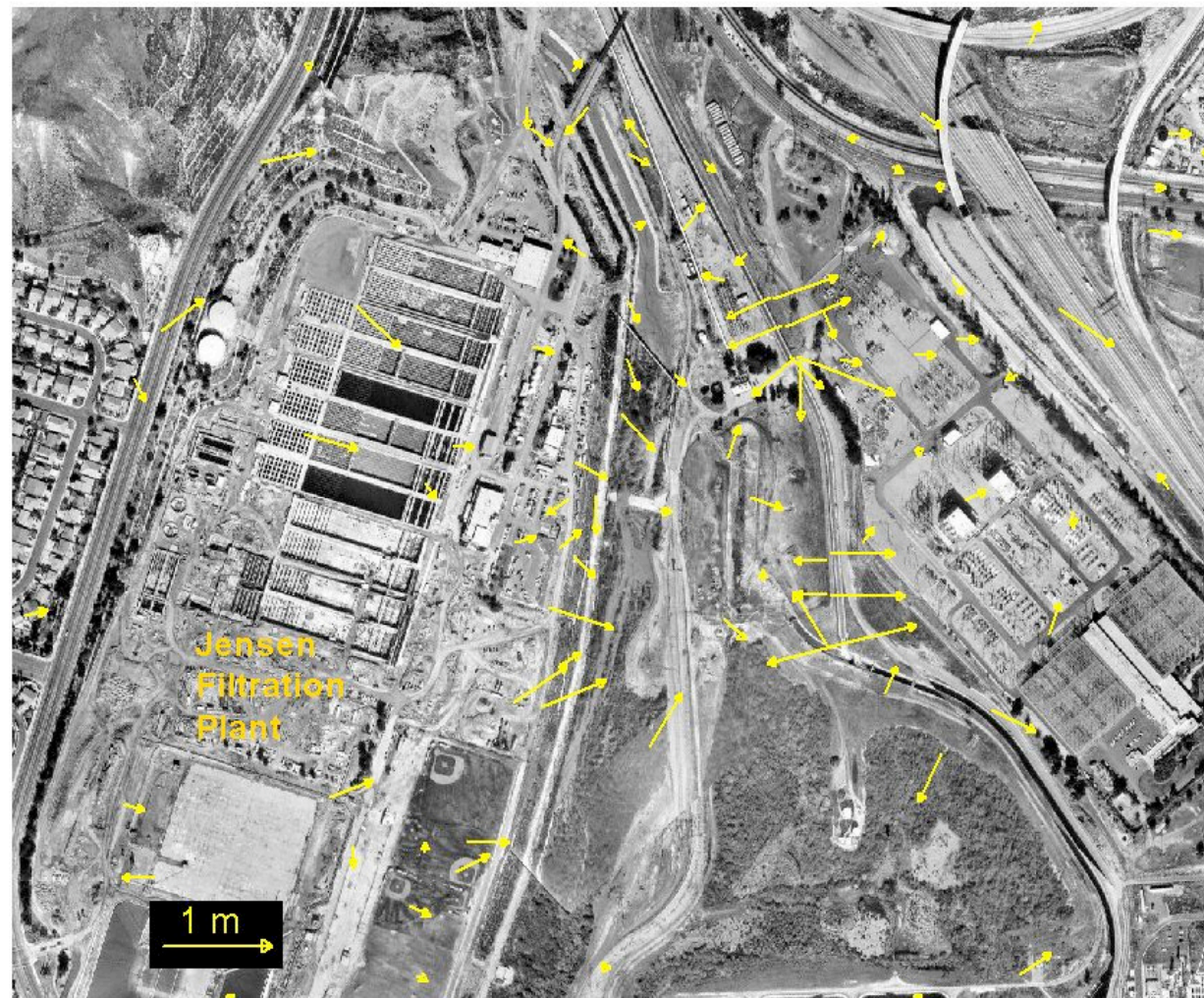


- **Airborne Stereo Photogrammetry**
  - Elevation maps
  - Displacement (false relief)/ Soil liquefaction
- **Airborne LIDAR**
  - High-resolution elevation maps
  - Coastal erosion
- **Landsliding**
  - Satellite/Optical imagery

- Civil engineers are mainly using optical data
  - Photogrammetry from aerial photographs
  - Displacements from photogrammetry
  - Visual analysis of damage using satellite imagery
  - Altimetry
- Civil engineers are moving toward
  - LIDAR for 3D images
  - inSAR and PSinSAR
- Civil engineers have still to explore other more sophisticated remote sensing, e.g. hyperspectral sensing.

# Ground Displacements from Stereo Photogrammetry

1971 San  
Fernando  
earthquake



# Soil Liquefaction

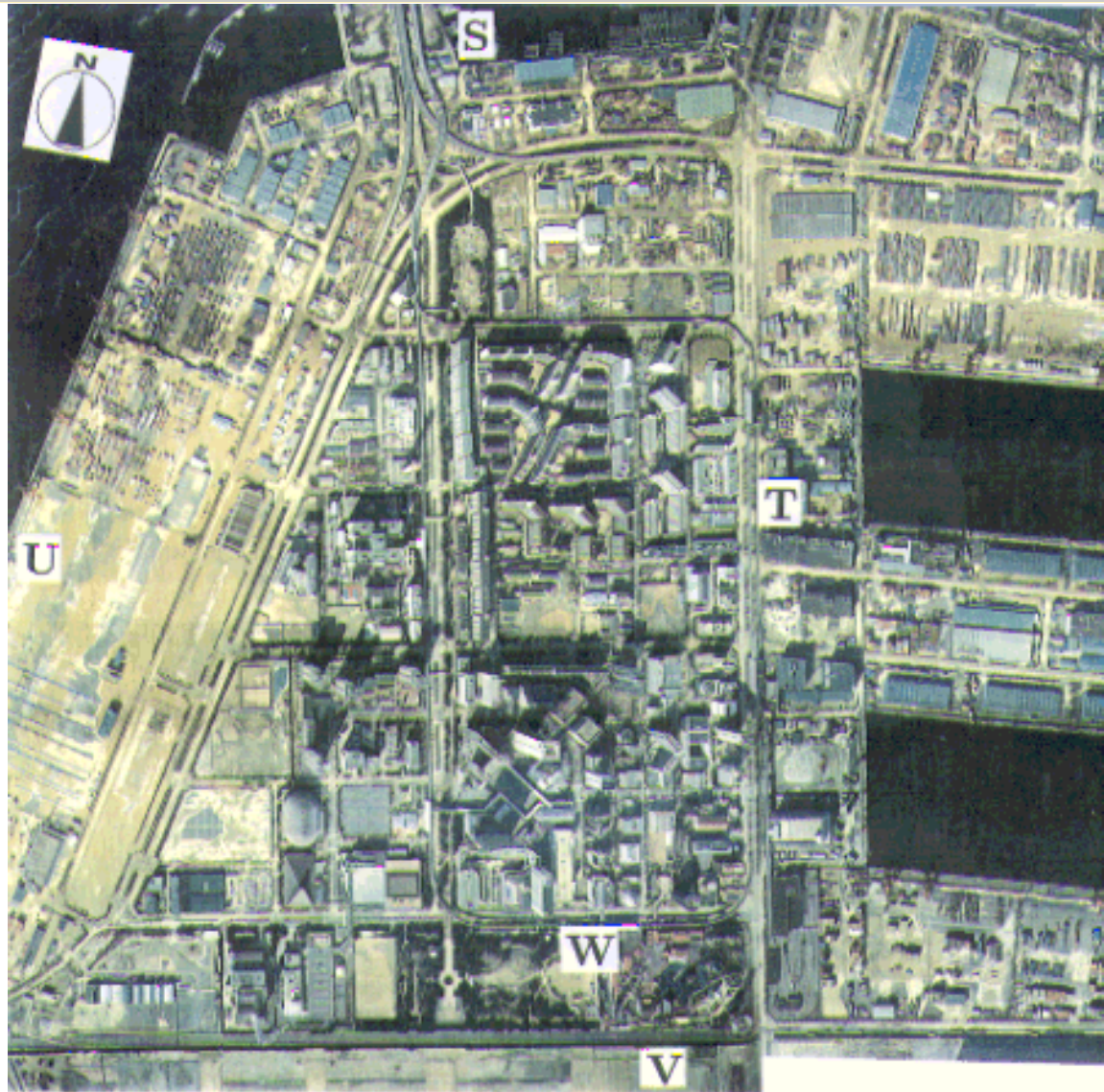


1964 Niigata earthquake



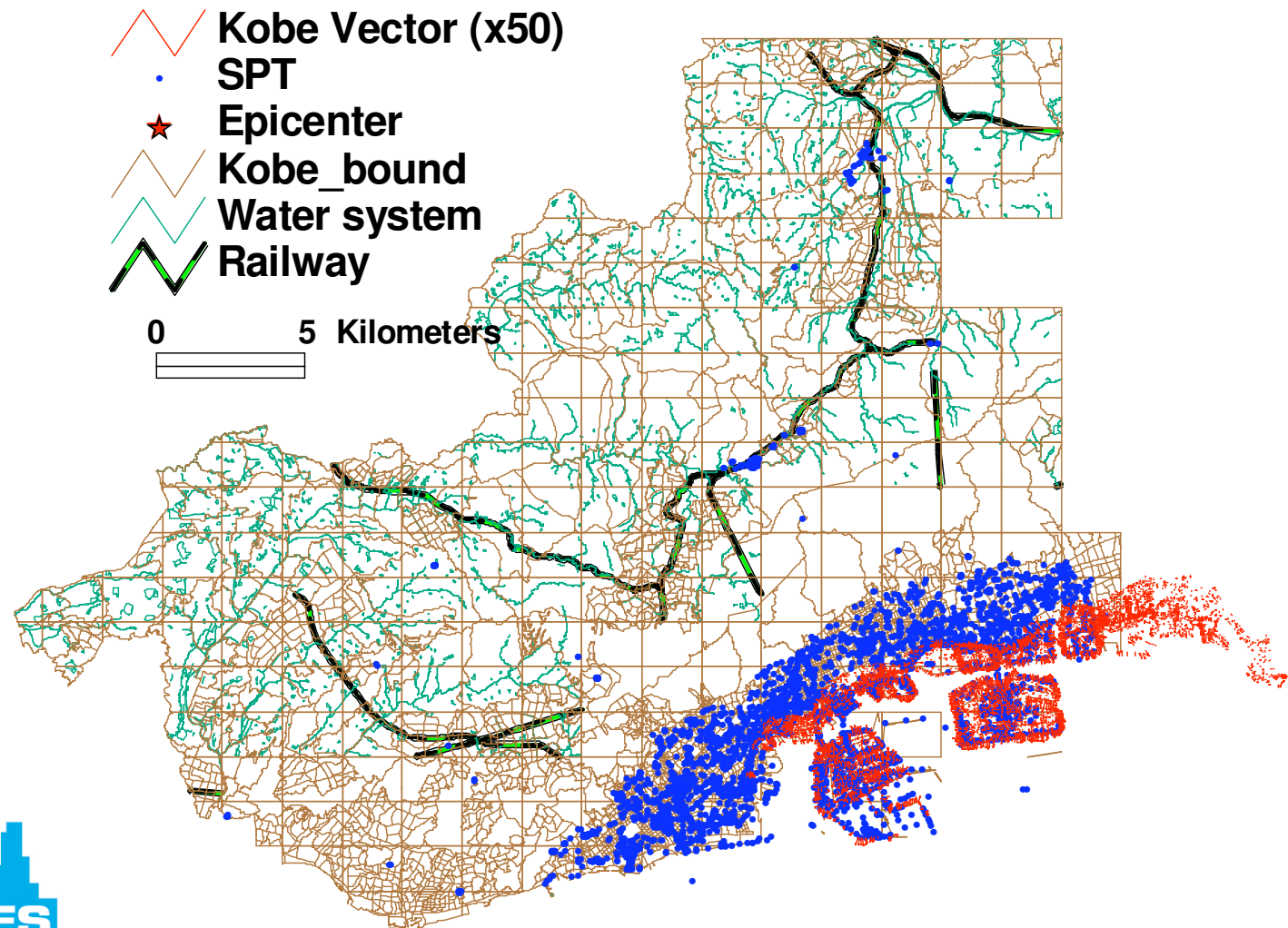
## 1995 Kobe earthquake, Port Island

Courtesy of  
M. Hamada

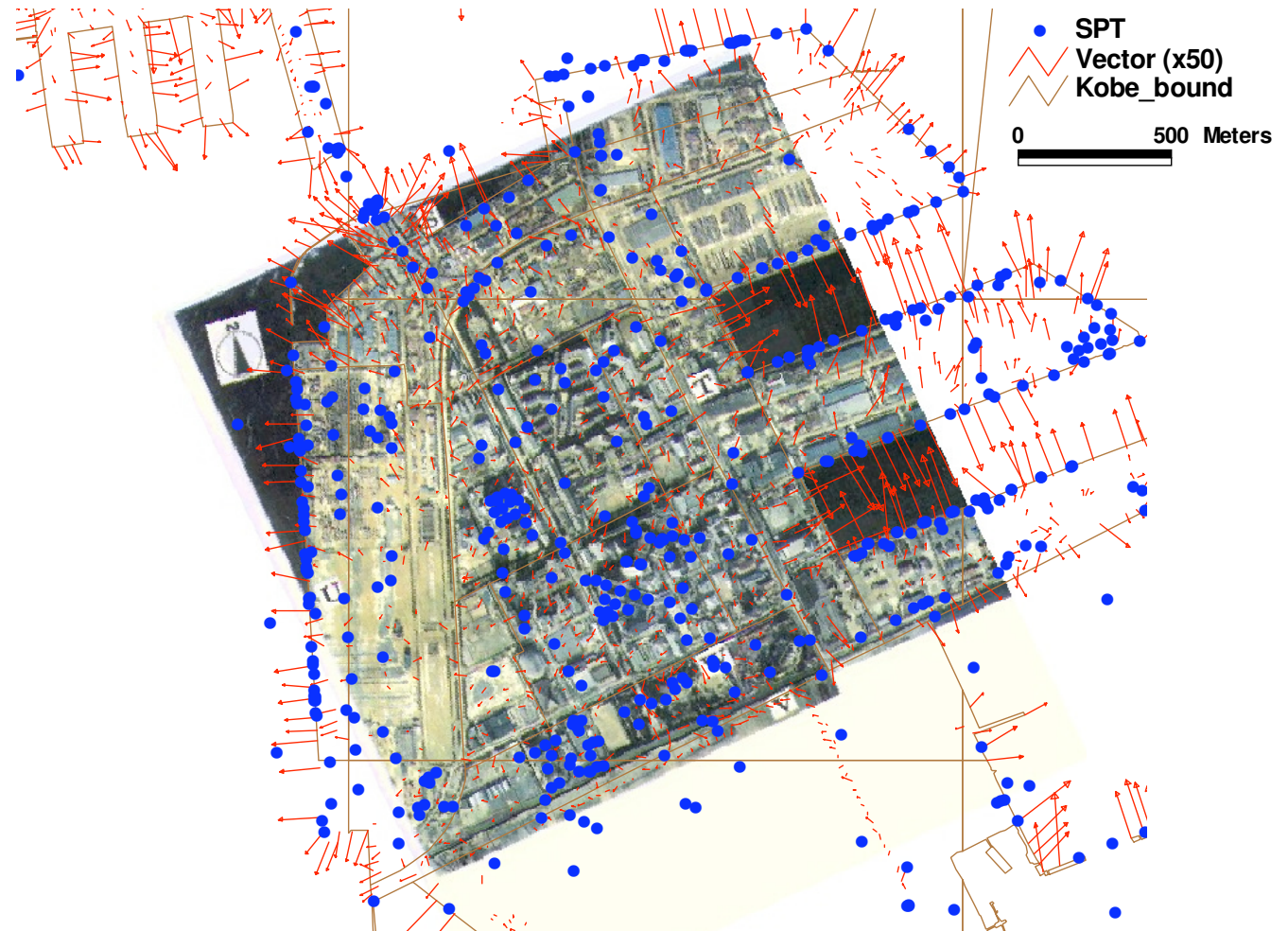


# Liquefaction-Induced Ground Deformation

1995 Kobe

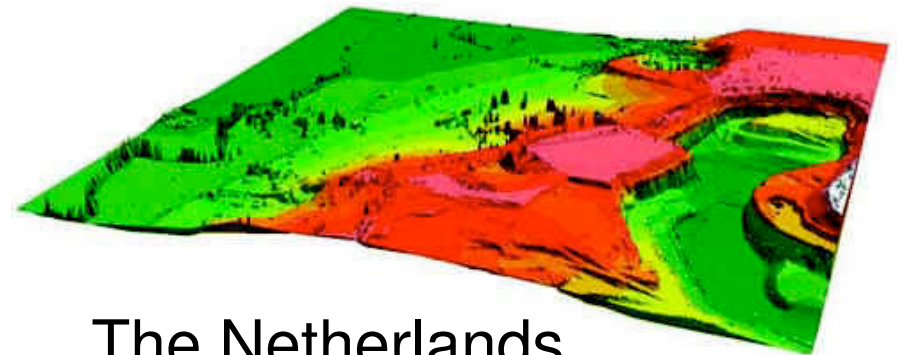
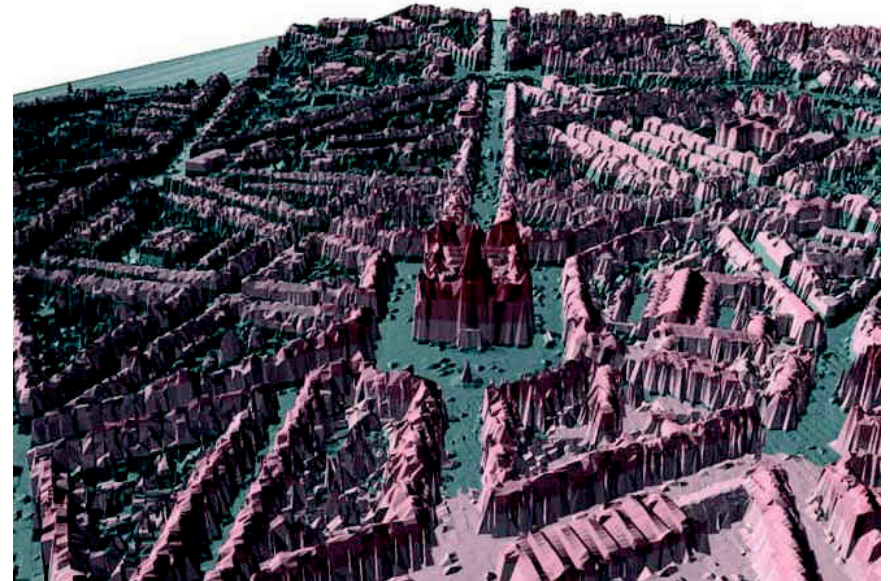
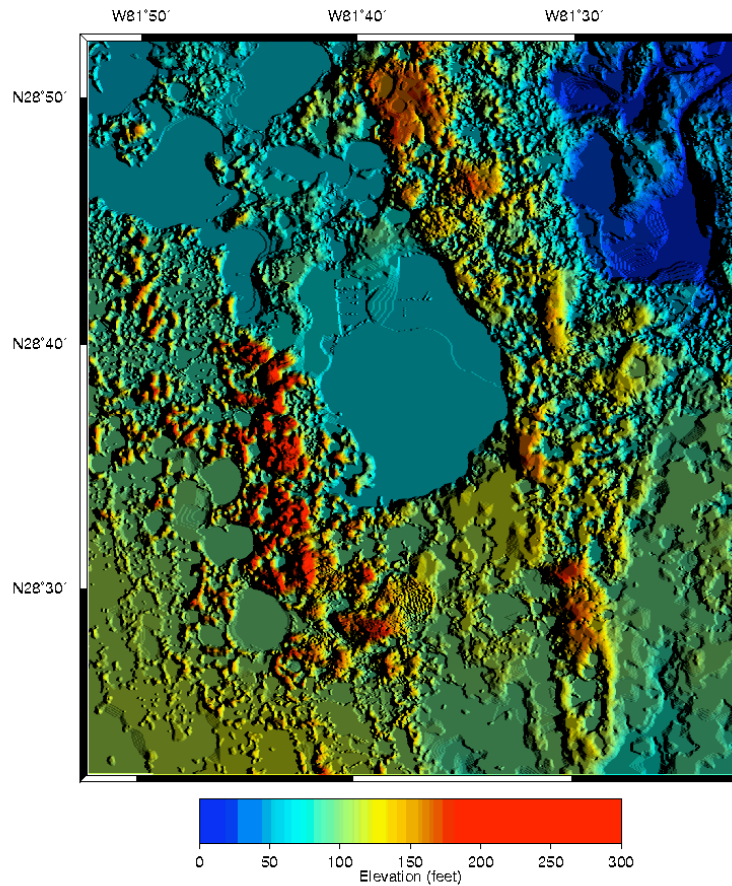


# Spatial Analysis in Port Island, Japan

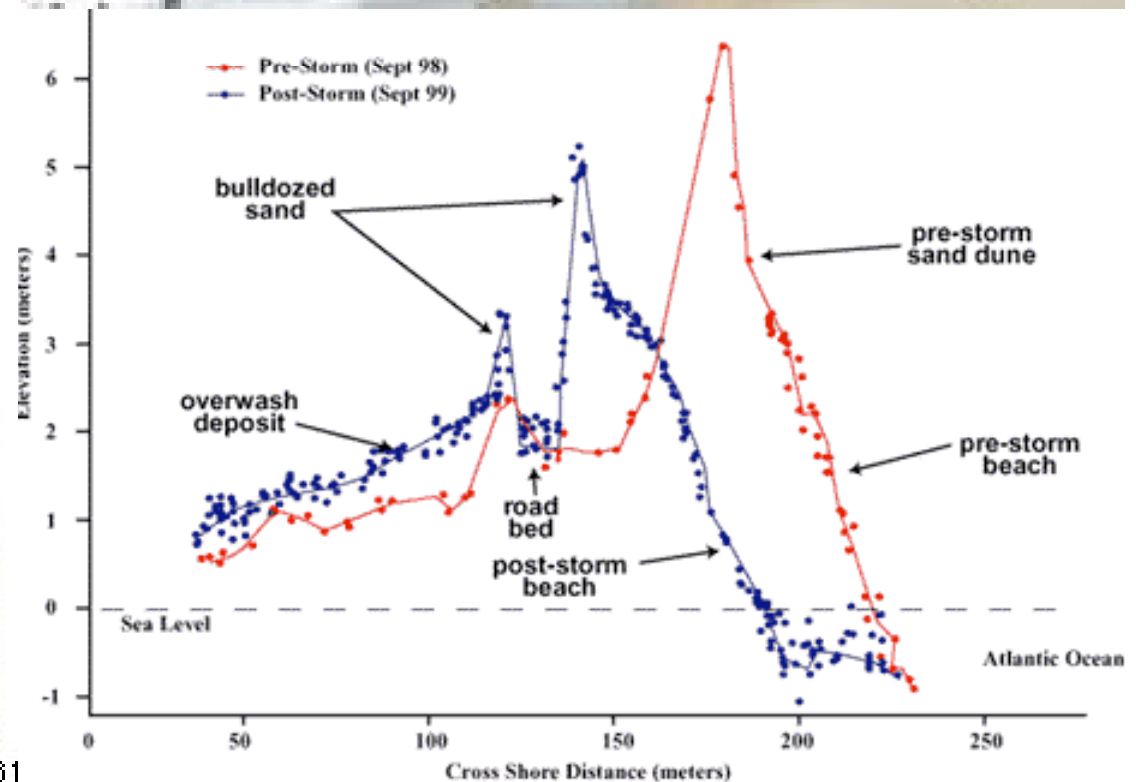
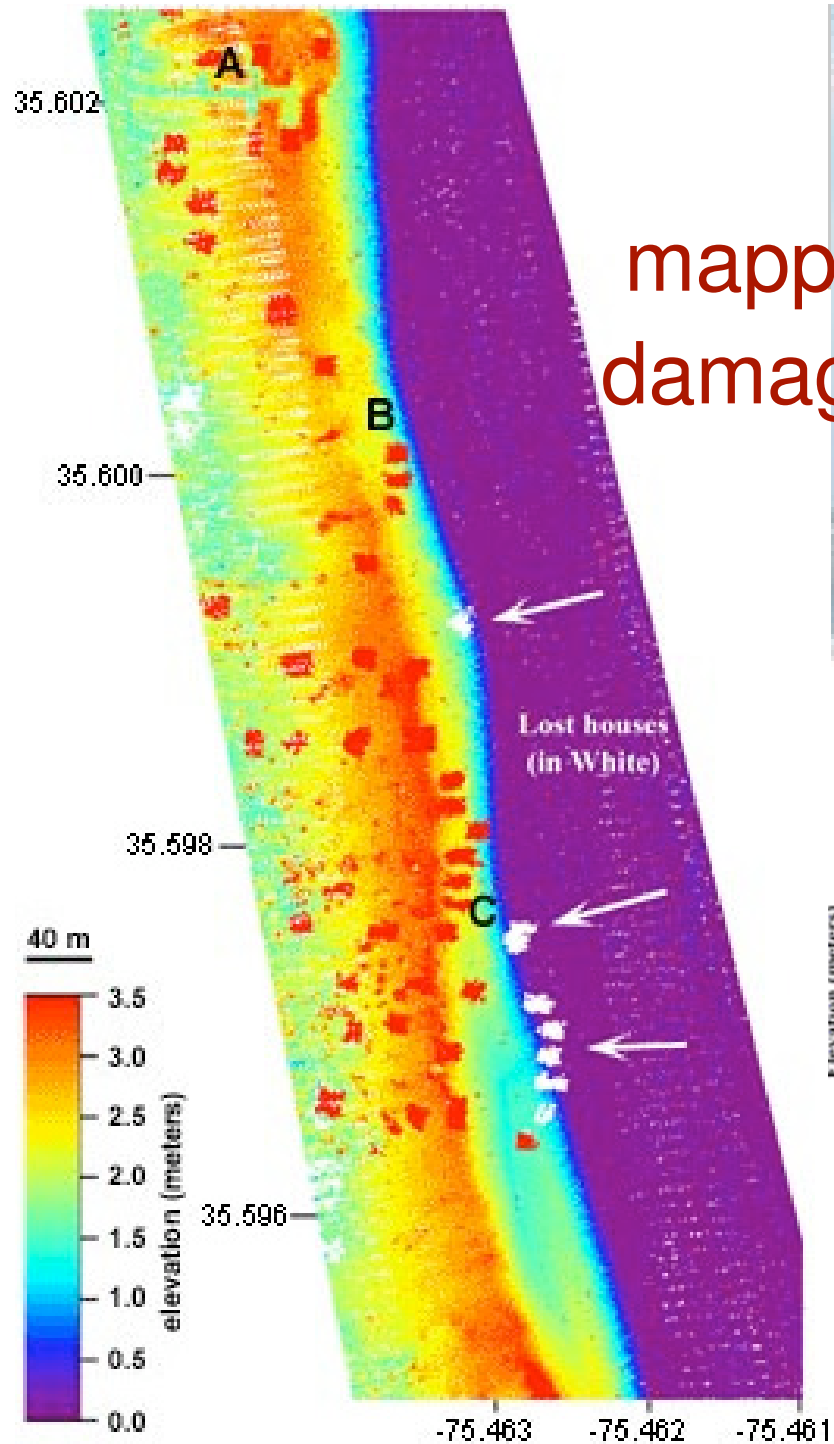


Measured  
displacement and  
geotechnical  
boreholes

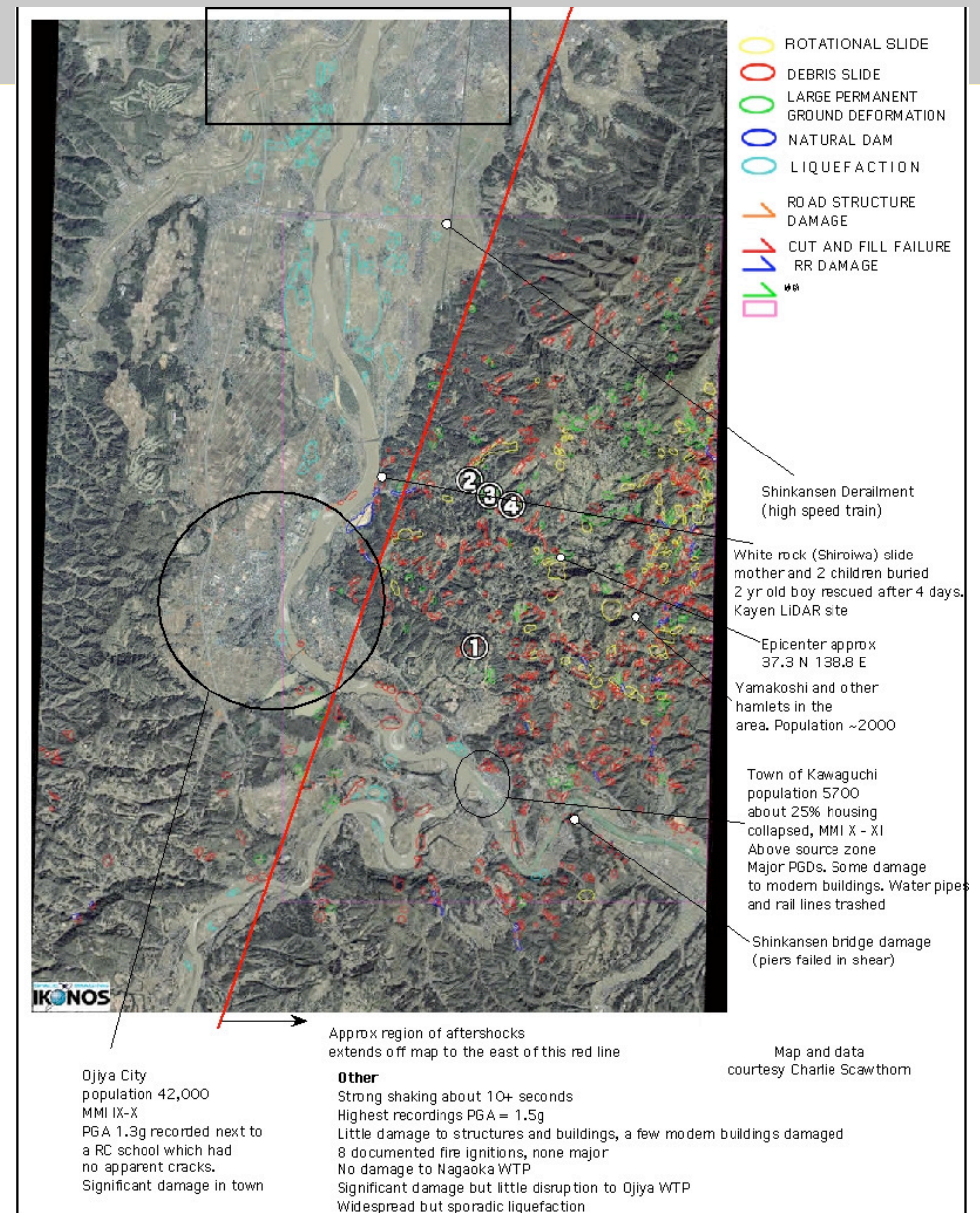
# Laser Altimetry: High Resolution Topography



# NOAA/USGS mapping of coastal damage after storm

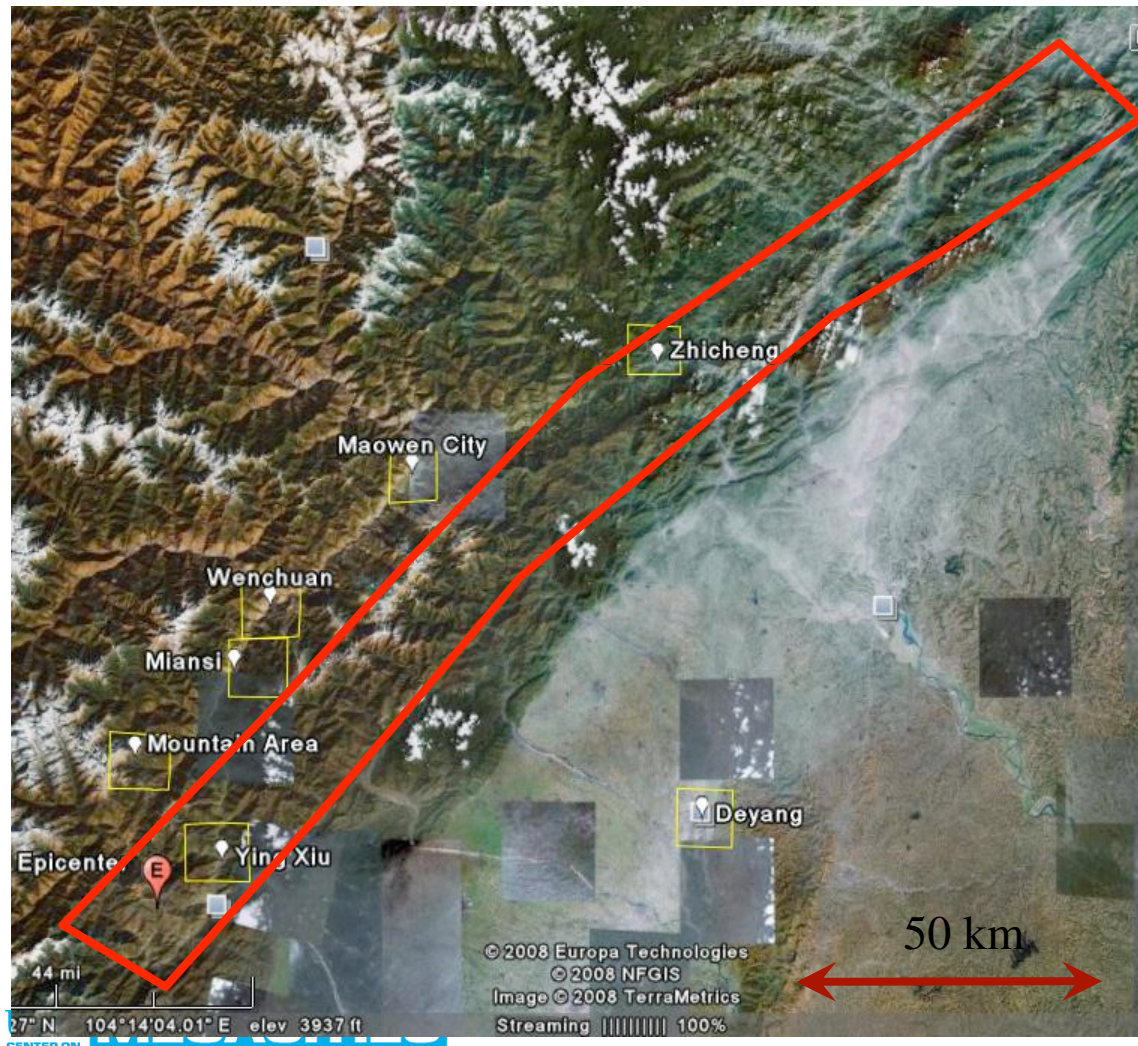


- Reconnaissance of 2004 Niigata-ken Chuetsu Earthquake in Japan
  - Thousands of landslides
  - Difficult access
- Annotated IKONOS image from C. Scawthorn of Kyoto University
  - Landslides visually identified
  - Liquefaction identified
  - Notes regarding damage, ground motions, previous reconnaissance activities



# 2008 Wenchuan Earthquake

*M 7.9m, ~ 200 km of fault rupture*



- Affected area larger than 10,000 km<sup>2</sup>
- Significant landslides in mountainous area
- Courtesy of Rathje, 2010



# Wenchuan Earthquake



- LANDSAT Imagery
  - Cloud-free pre-event imagery (April 2007/2008)
  - Post-event imagery (May 2008) with significant cloud cover at edge of mountains
- High-resolution data
  - Post-event IKONOS (IK) imagery purchased by USGS and made available to researchers
  - Pre- and post-event Quickbird (QB) imagery purchased by Remote Sensing Consortium over localized areas

# Landslide Identification

Pre-event  
LANDSAT



~ 5 km x 5 km area

Post-event  
LANDSAT



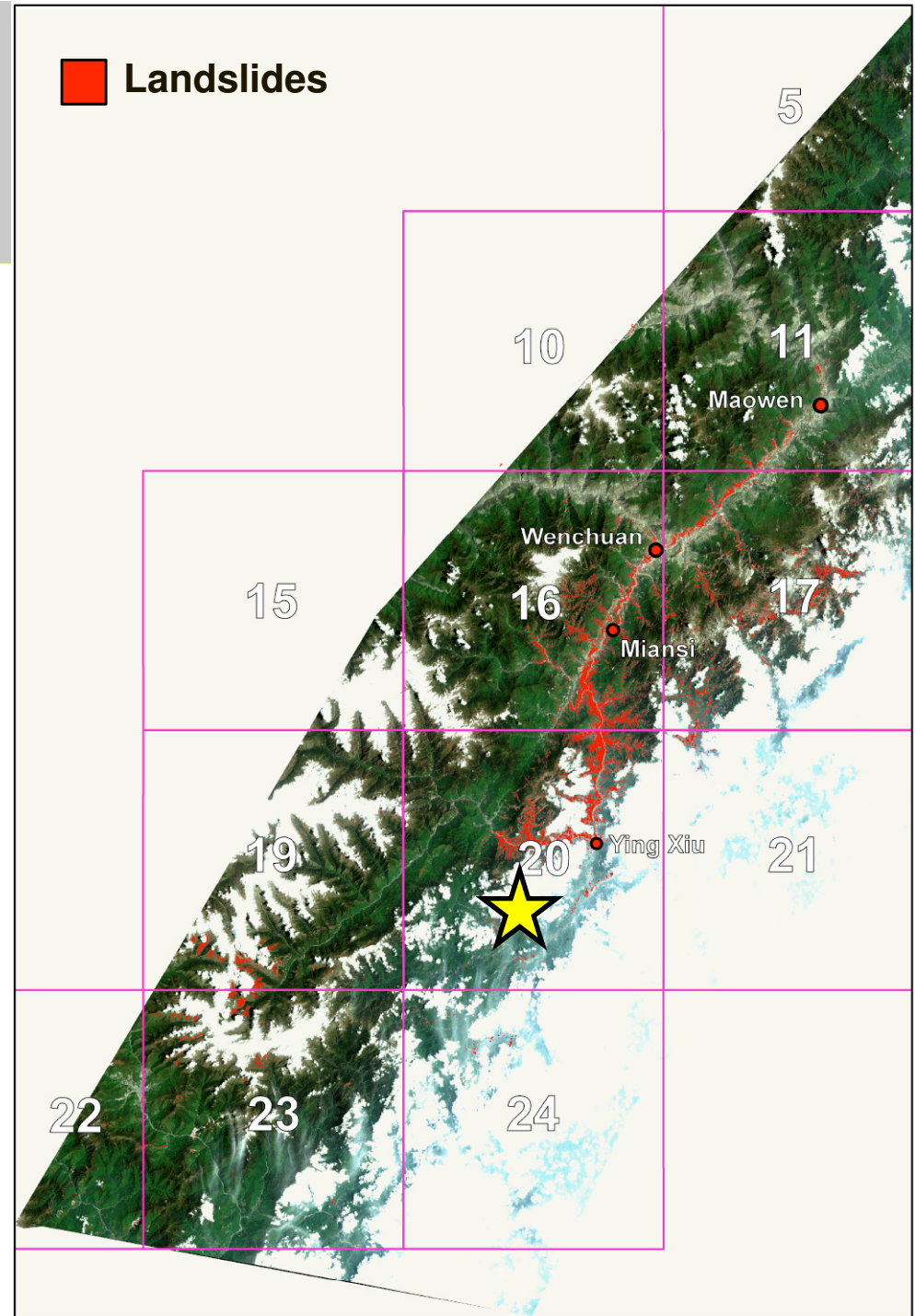
Post-event IKONOS



Courtesy of E. Rathje

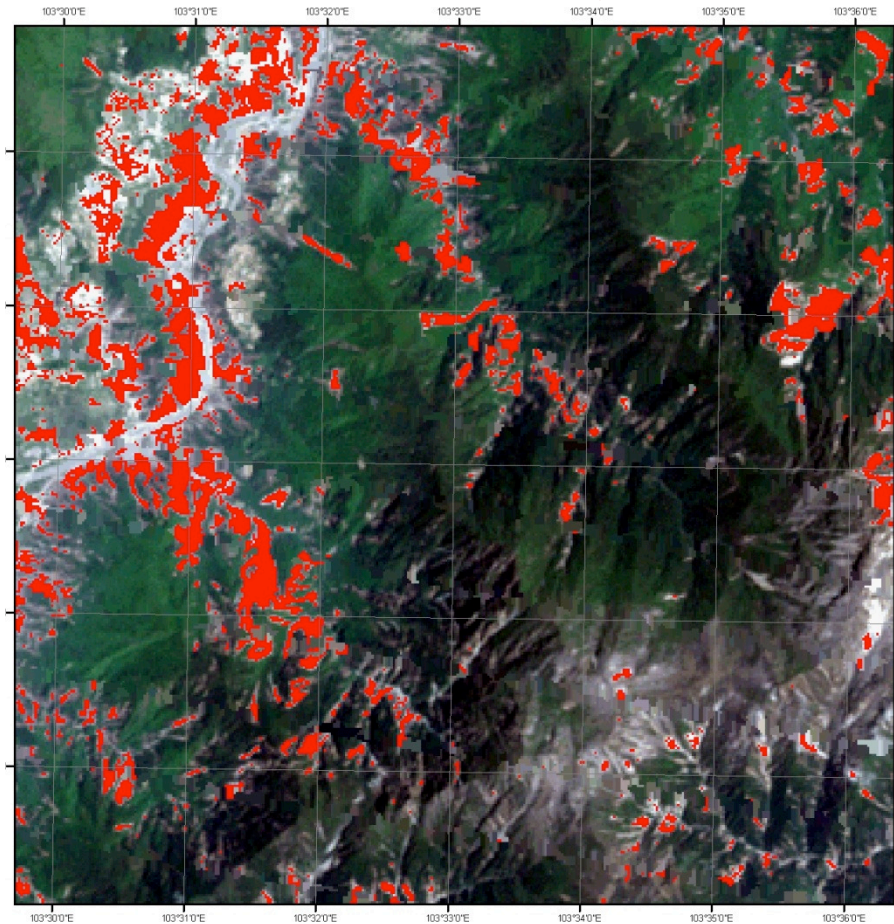
# Wenchuan EQ

- Heavy concentration of landslides near Ying Xiu and Miansi
- Fewer landslides to the west of epicenter
- Courtesy of E. Rathje

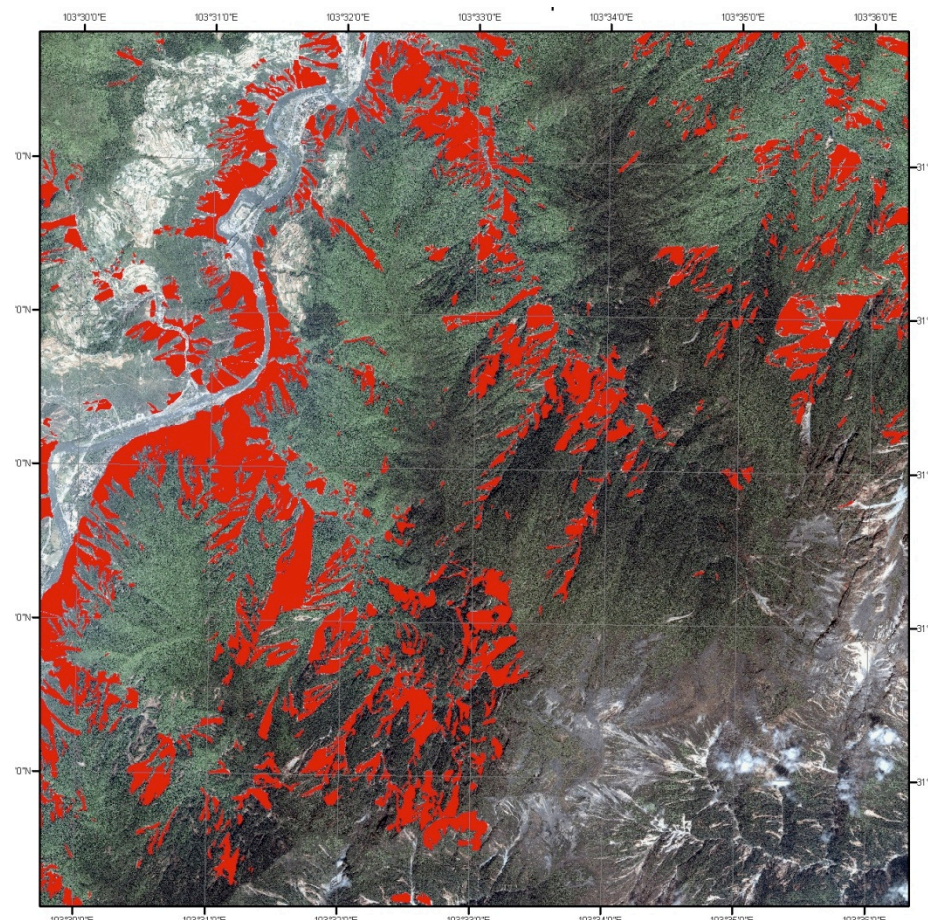


# Miansi (PGA~0.92 g)

*LANDSAT Analysis*



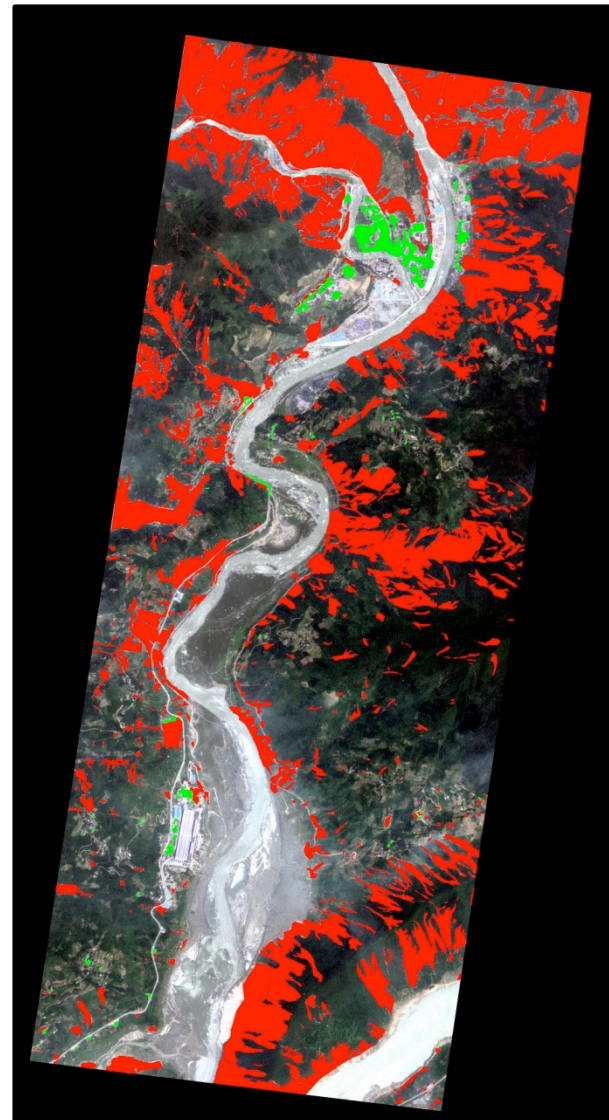
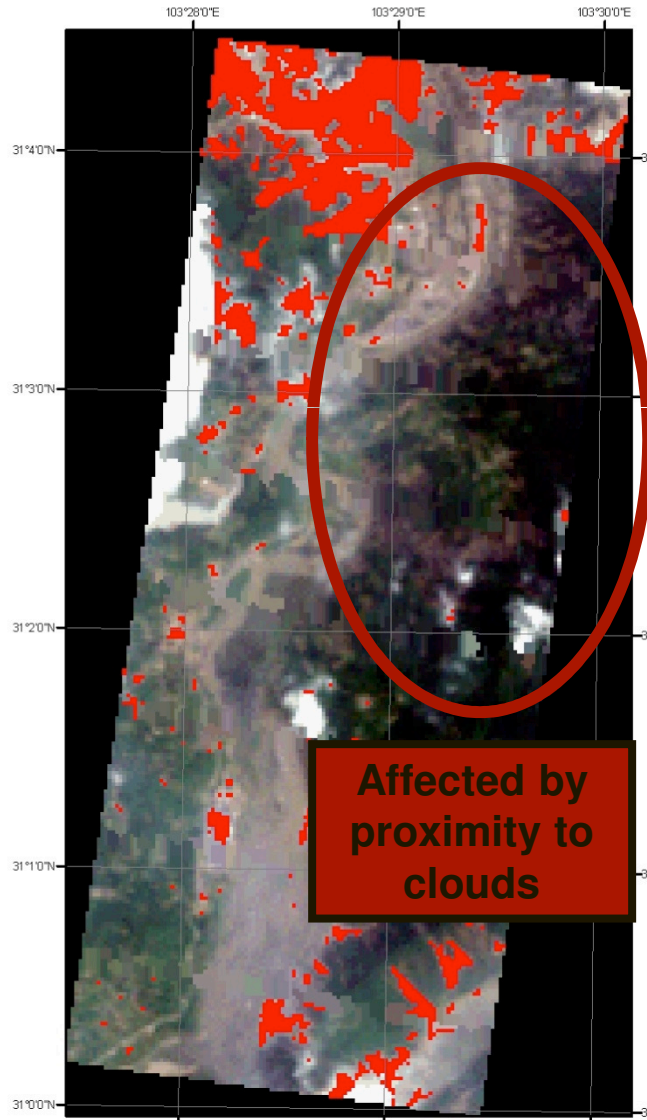
*IK Visual Interpretation*



# Ying Xiu (PGA~0.96 g)

## *LANDSAT Analysis*

## *QB Visual Interpretation*



 Landslides

 Urban damage

2 km



Courtesy of  
E. Rathje

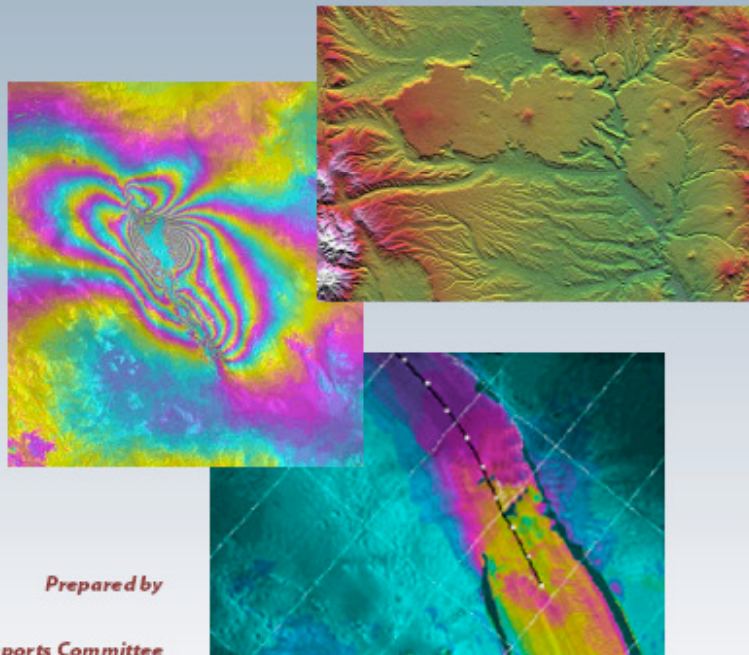
- **Damage assessment**
  - Earthquake/ Change in reflectance
- **Ground subsidence due to water removal**
- **Tectonic strains around faults**
- **Landsliding**
  - Small displacement/large areas

# InSAR Workshop Summary Report

October 20–22, 2004

Oxnard, California

Sponsored by: National Aeronautics and Space Administration (NASA),  
National Science Foundation (NSF), and United States Geological  
Survey (USGS)



Prepared by  
Reports Committee  
InSAR Working Group

Table Key	Societal Benefit Areas									SAR Imagery	SAR Interferometry
	Weather	Disasters	Oceans	Climate	Agriculture	Human Health	Ecology	Water	Energy		
H = High level of importance to benefit area											
M = Medium level of importance to benefit area											
L = Low level of importance to benefit area											
Earth Observations Note: This list of observations is not meant to be comprehensive											
Land Elevation/Topography	M	H	H	M	H	M	H	H	L	●	●
Land Use/Land Cover (Crops, Forests, Urban, etc.)	M	M	L	M	H	H	H	M	M	●	●
Ecosystem Parameters (Health, Diversity, etc.)	L	L	H	H	H	H	H	M	L		
Ris (Detection, Extent, Severity)	L	H	L	M	H	H	H	M	L	●	
Soil Moisture	M	M	L	H	H	H	M	H	L	●	●
Ice and Snow (Cover and Volume)	M	M	M	H	M	M	M	H	M	●	●
Land and Sea Surface Temperature	H	H	H	H	H	H	H	M	H		
River Runoff (Volume, Sediment, etc.)	L	H	H	H	H	H	H	H	H	●	●
Water Quality (Contamination, Spills, etc.)	L	H	H	M	H	H	H	H	L	●	
Sea Surface Height/Topography	L	M	H	H	L	M	H	L	L	●	●
Ocean Current and Circulation	M	L	H	H	L	L	H	L	L	●	●
Ocean Salinity	L	L	H	H	L	L	H	L	L		
Ocean Color (Chlorophyll, etc.)	L	L	H	M	L	H	H	L	L		
Atmospheric Constituents (Ozone, Greenhouse Gases, Black Carbon, Volcanic Ash, and Other Aerosols, etc.)	L	H	M	H	L	H	L	H	H		
Atmospheric Profiles (Temperature, Pressure, Water Vapor)	H	H	L	H	L	M	L	L	L		
Wind Speed and Direction (Surface, Tropospheric, Stratospheric)	H	H	H	H	M	H	M	L	L	●	
Cloud Cover (Properties, Type, Height)	H	M	M	H	M	L	L	L	L		
Total and Clear Sky Radiative Flux	H	L	M	H	H	H	M	M	H		
Solar Irradiance	L	L	L	H	L	H	M	L	L		
Space Weather	L	H	L	L	L	M	L	L	H		
Deformation/Subsidence/ Ground Failure	L	H	M	L	L	L	L	M	L	●	●
Earthquake and Volcanic Activity, Gravity, Magnetic Field Variations	L	H	L	M	L	L	L	L	L	●	
Geology/Bedrock and Surface Soils	L	H	L	L	M	L	M	H	M	●	
Species (Occurrences, Density, etc.)	L	M	H	H	H	H	H	M	L	●	

# USC Viterbi

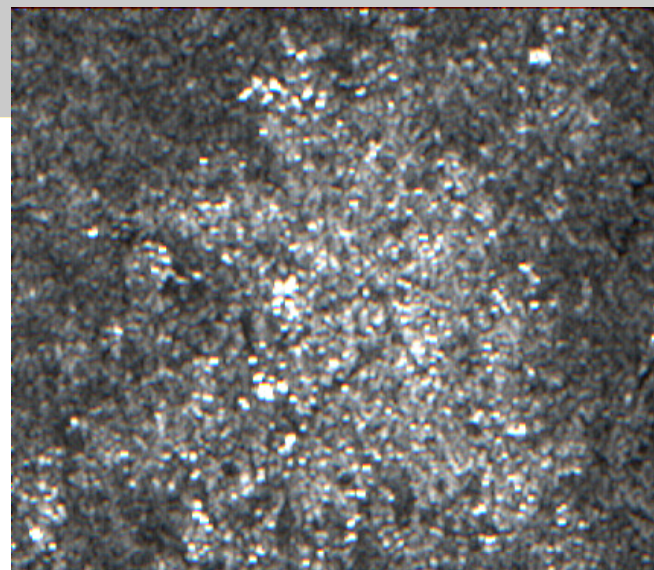
School of Engineering

LandSAT - Adapazari, Turkey

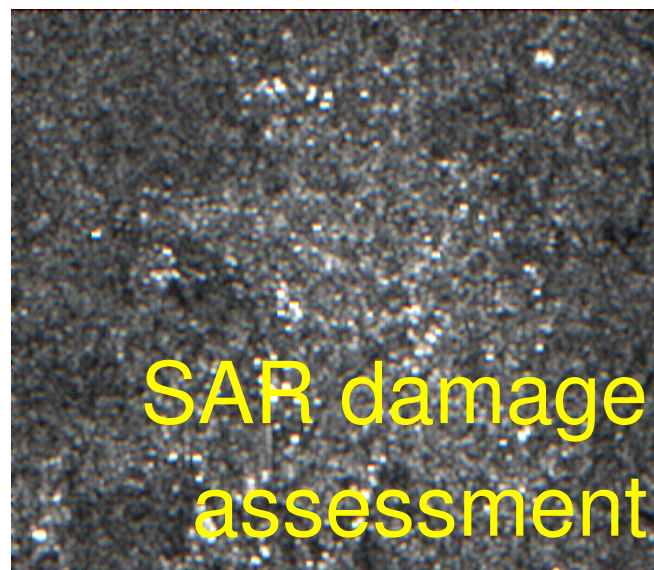


Courtesy of Shinozuka

SAR reflectance data  
Before Earthquake - 4/24/99

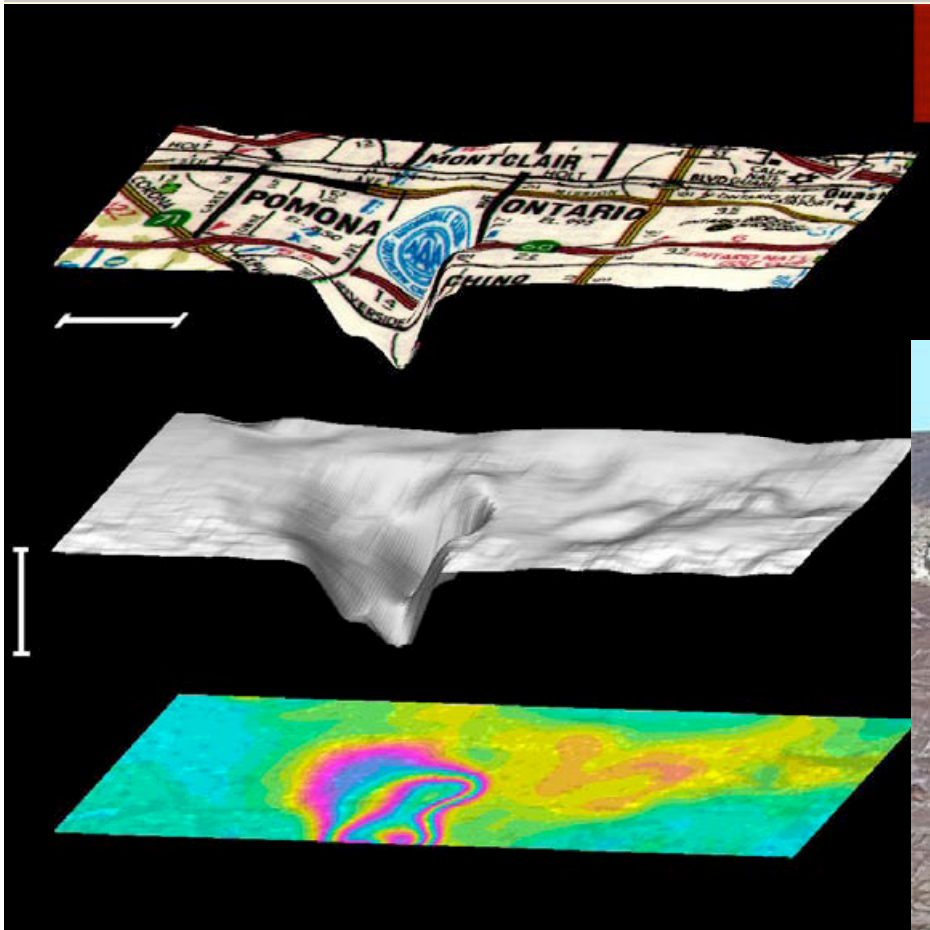


After Earthquake - 9/10/99

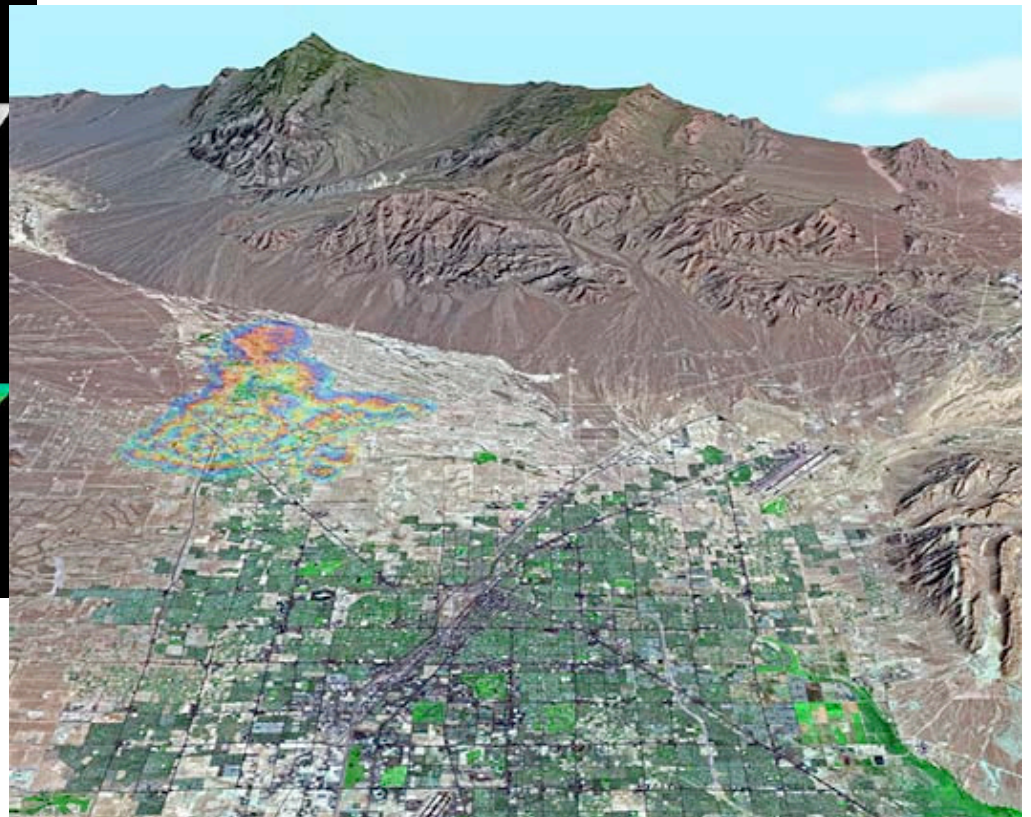


SAR damage  
assessment

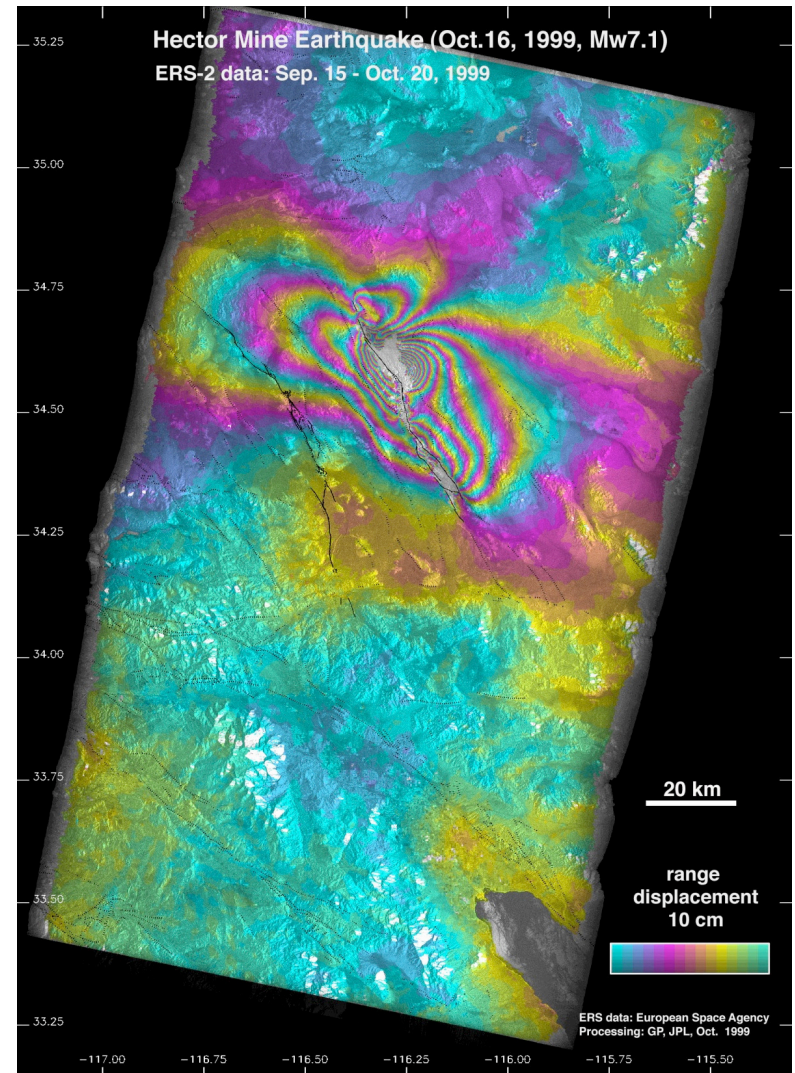
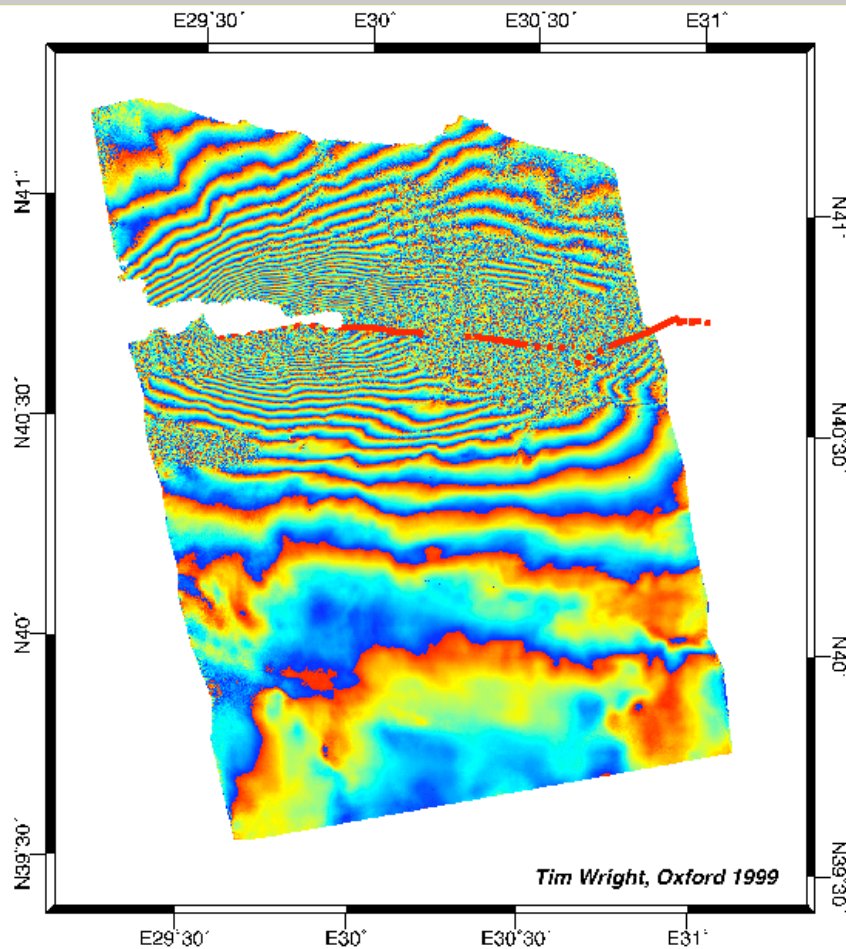
# SAR Interferometry: Ground Subsidence



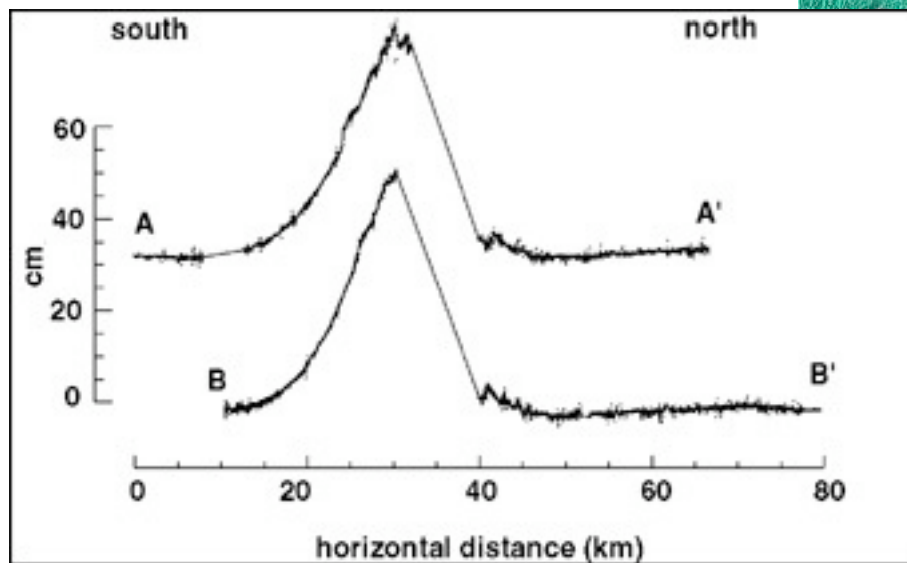
[www.npagroup.com](http://www.npagroup.com)



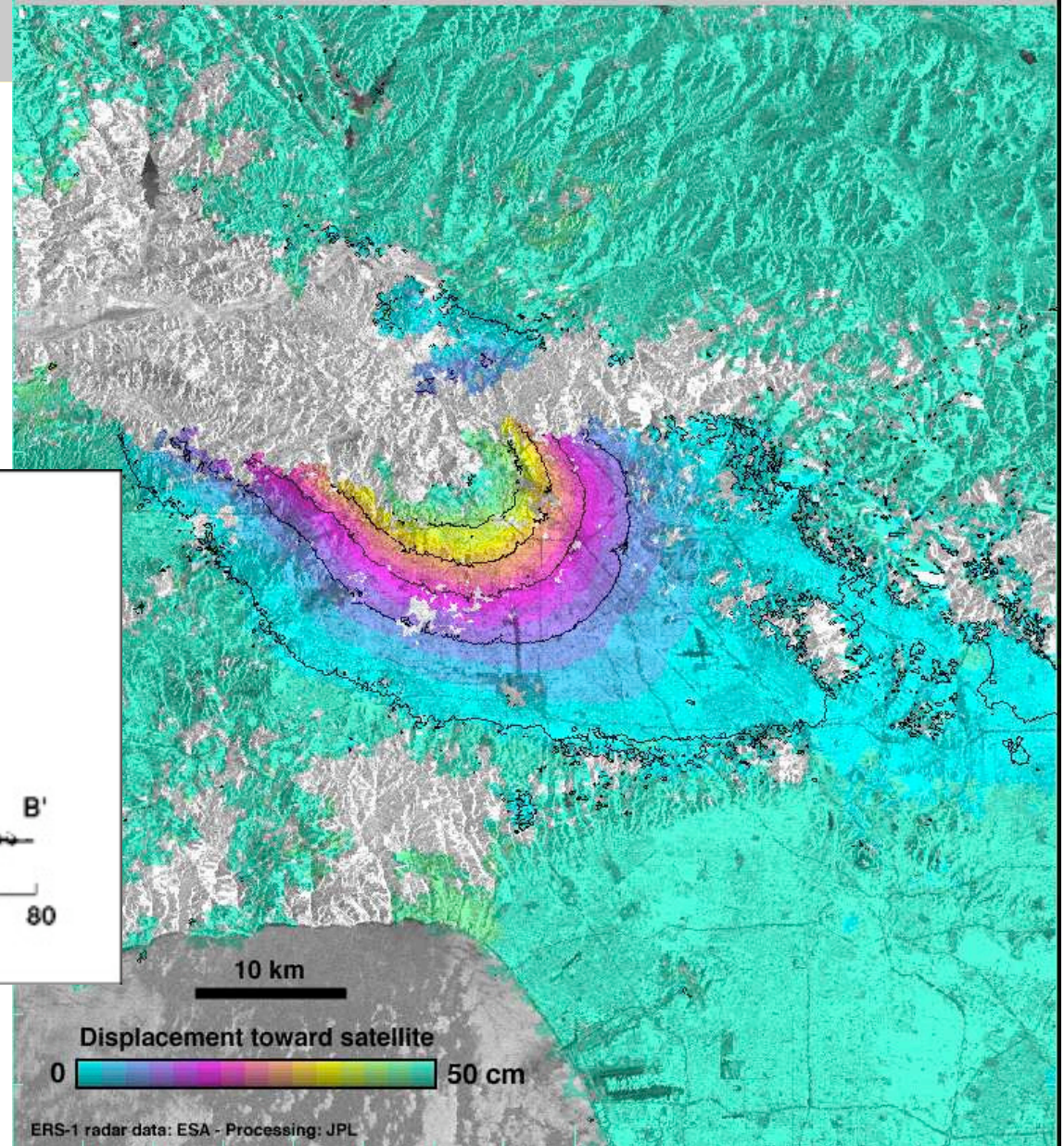
# SAR Interferometry: Tectonic Strain



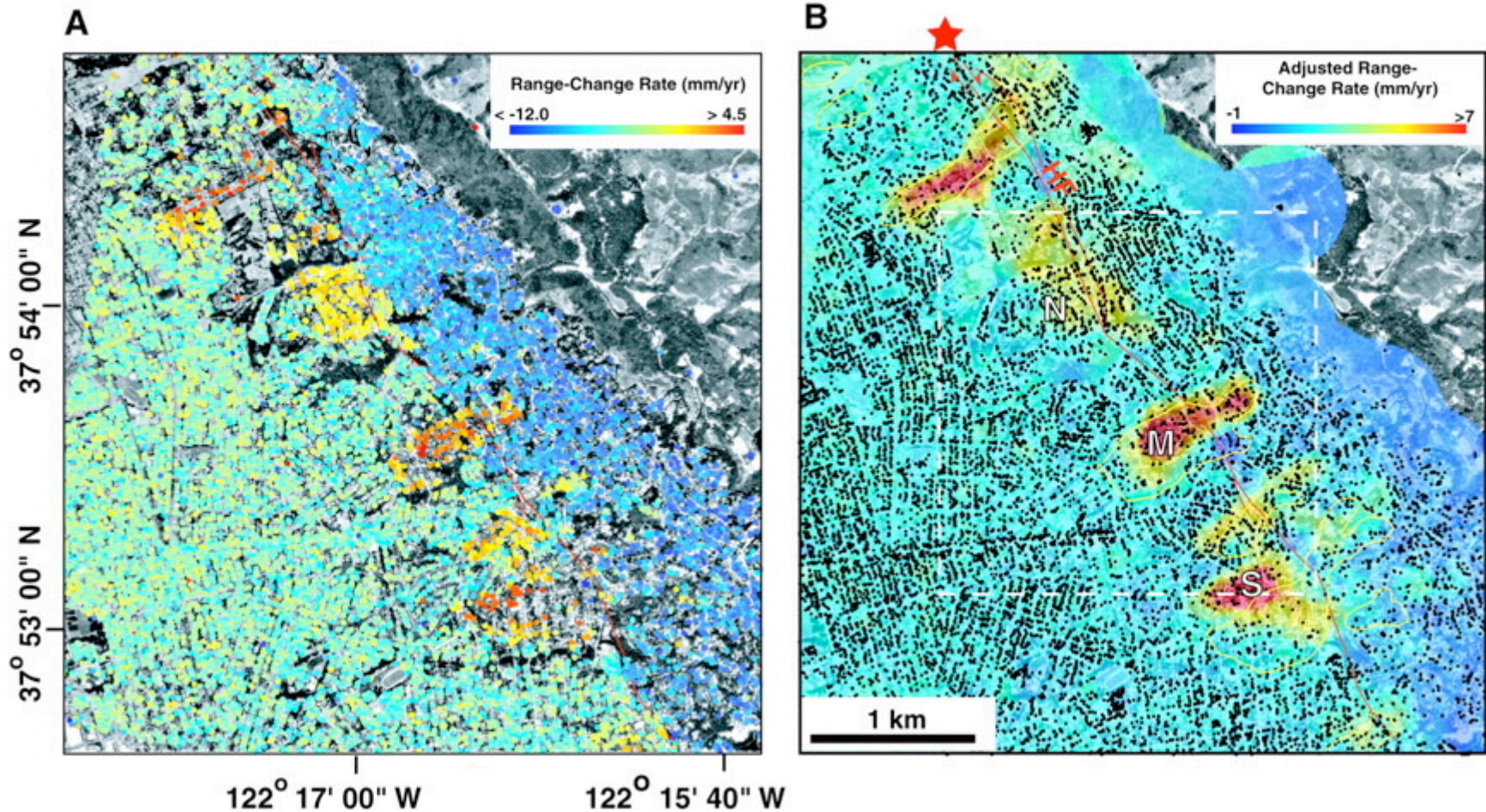
Courtesy of JPL SAR  
Inter-  
ferometry

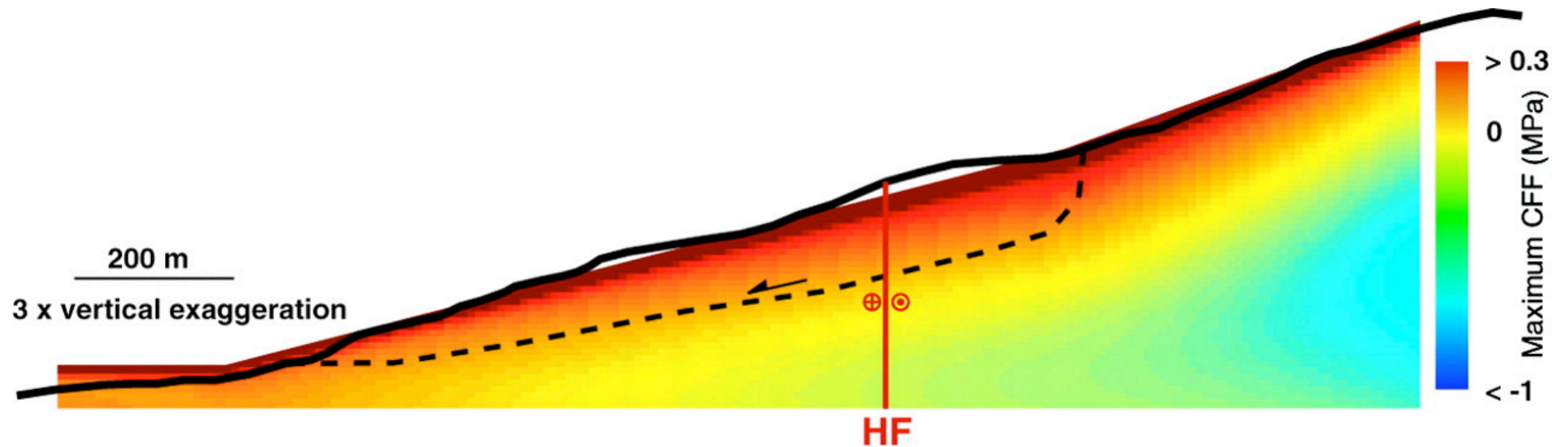


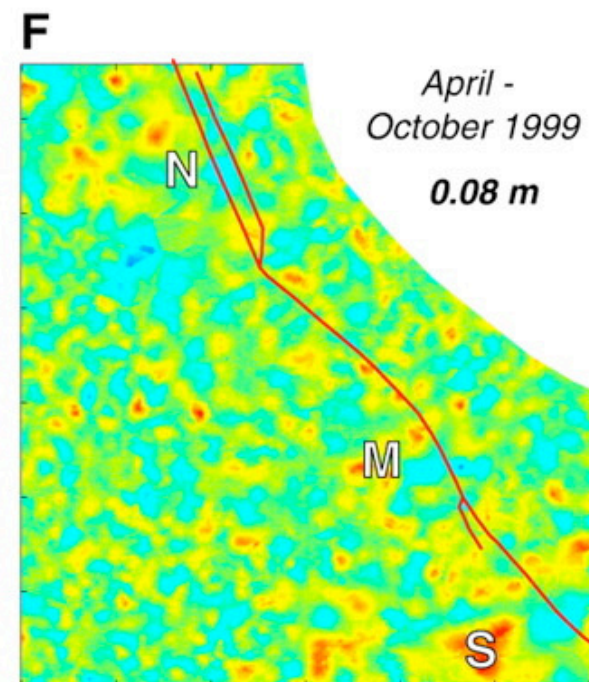
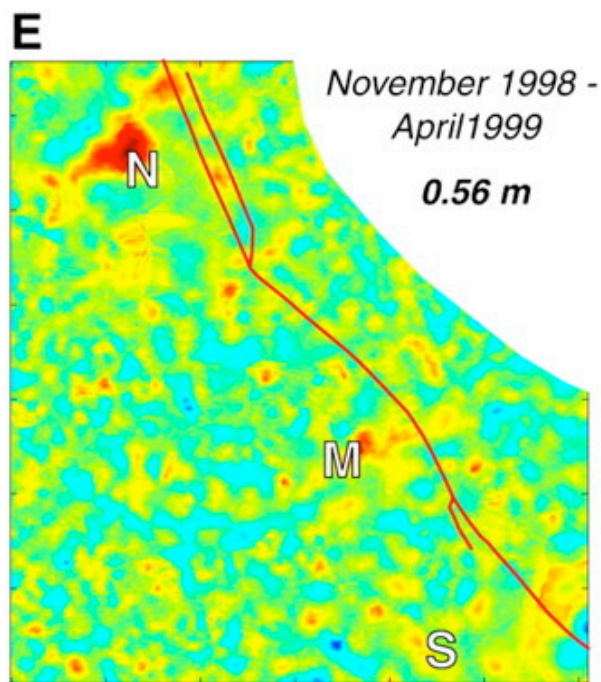
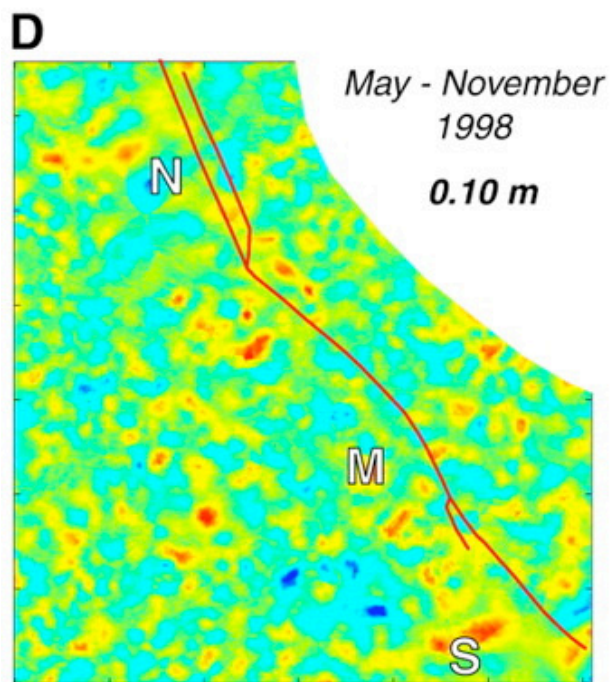
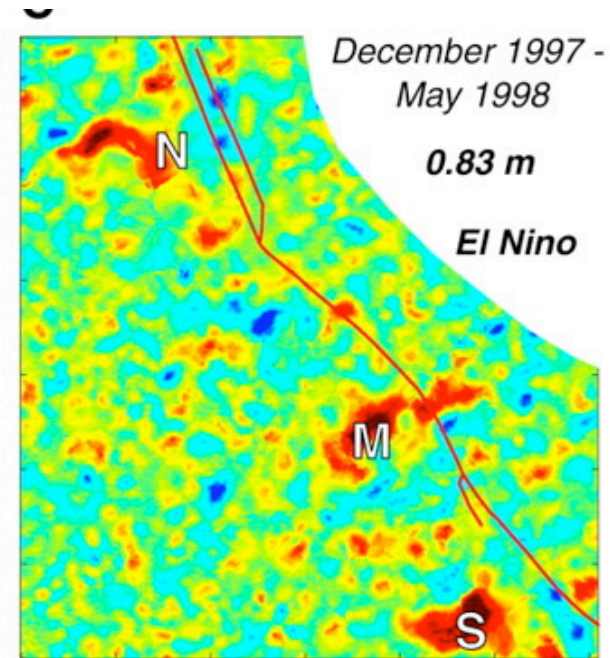
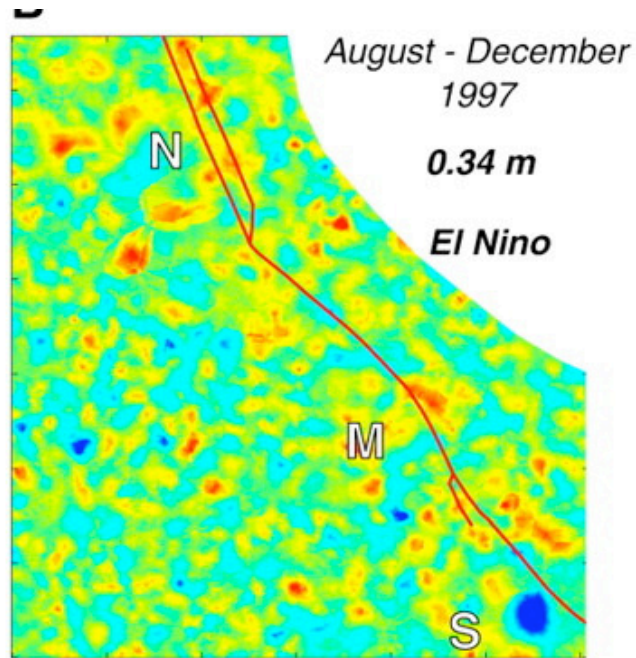
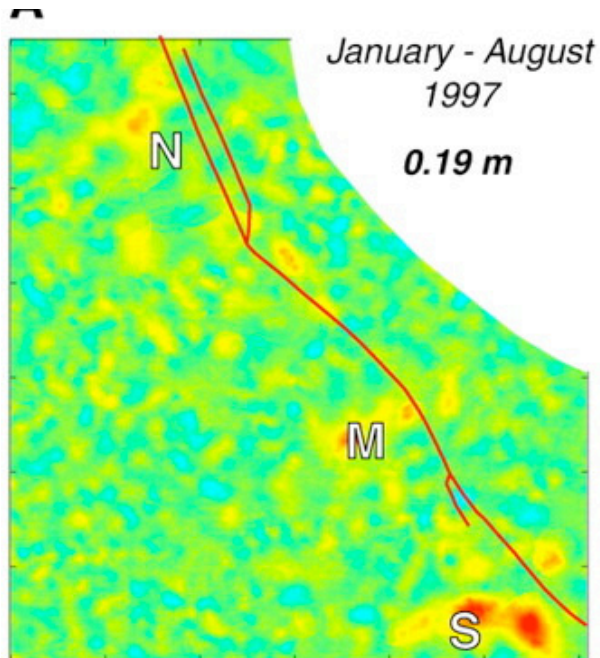
THE NORTHRIDGE, CALIFORNIA EARTHQUAKE ( $M_w=6.7$ )  
RADAR INTERFEROMETRIC MAP OF SURFACE DISPLACEMENT



# Permanent Scatterer InSAR







George E. Hilley et al, Science, 2004

1 km

Range-change Rate (mm/yr)



# USC Viterbi

School of Engineering



Jet Propulsion Laboratory  
California Institute of Technology

[+ NASA Home Page](#)

JPL HOME

EARTH

SOLAR SYSTEM

STARS & GALAXIES

SCIENCE & TECHNOLOGY

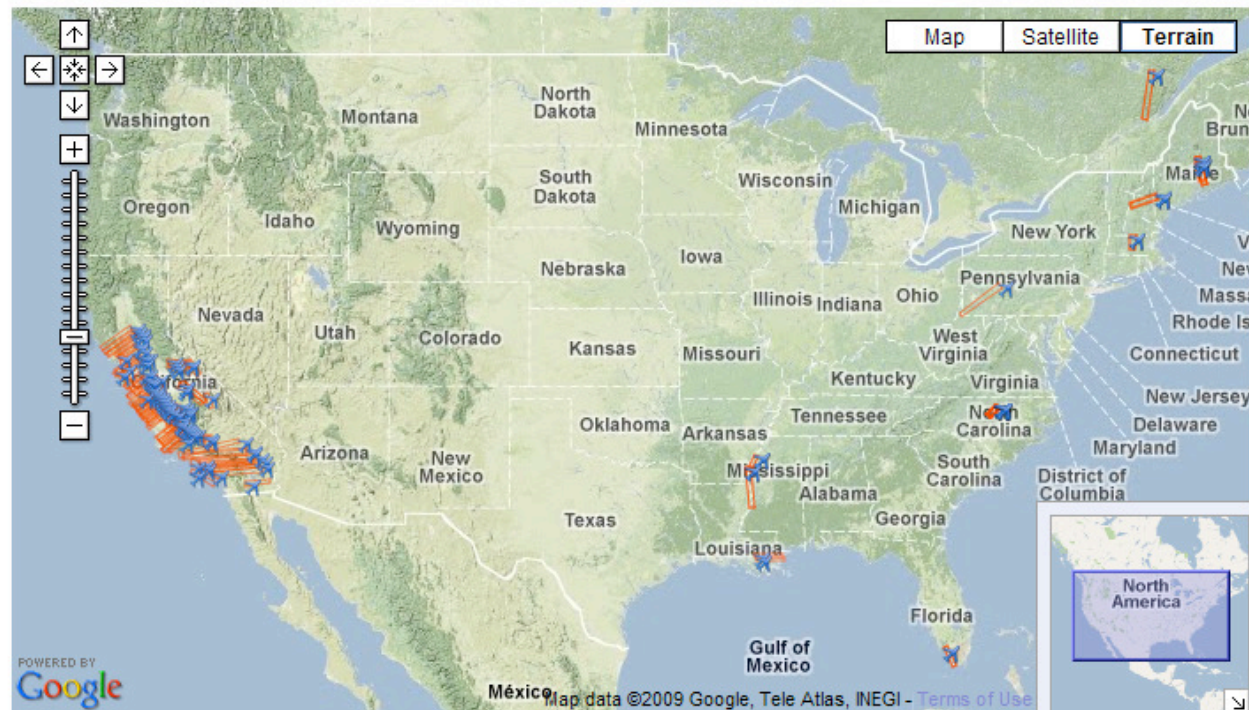
## UAVSAR

*Uninhabited Aerial Vehicle Synthetic Aperture Radar*



>Data:Data Search Map ([Switch to Text search](#))

Search  ALL



Total Number of flightlines with data on the map: 121

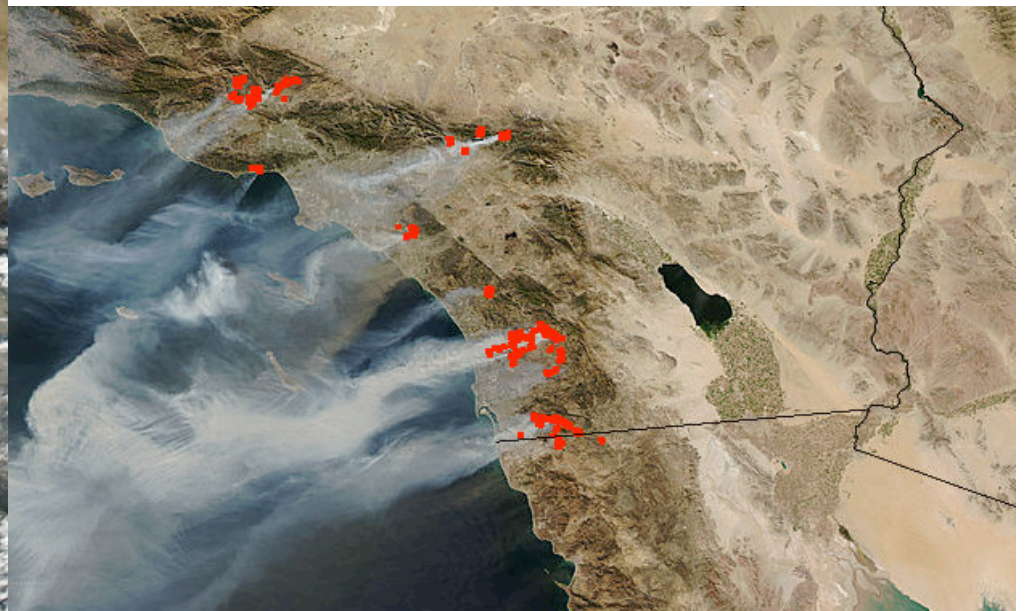
- PSinSAR freeware is not trivial to use for civil engineers
- Steep learning curve
- PSinSAR professional software is expensive
- High cost of SAR photos

## Other Applications in Civil Engineering

- Air Pollution
- Tsunamis
- Ground Deformation and Surface Faulting
- High Speed Rail
- Water Distribution System

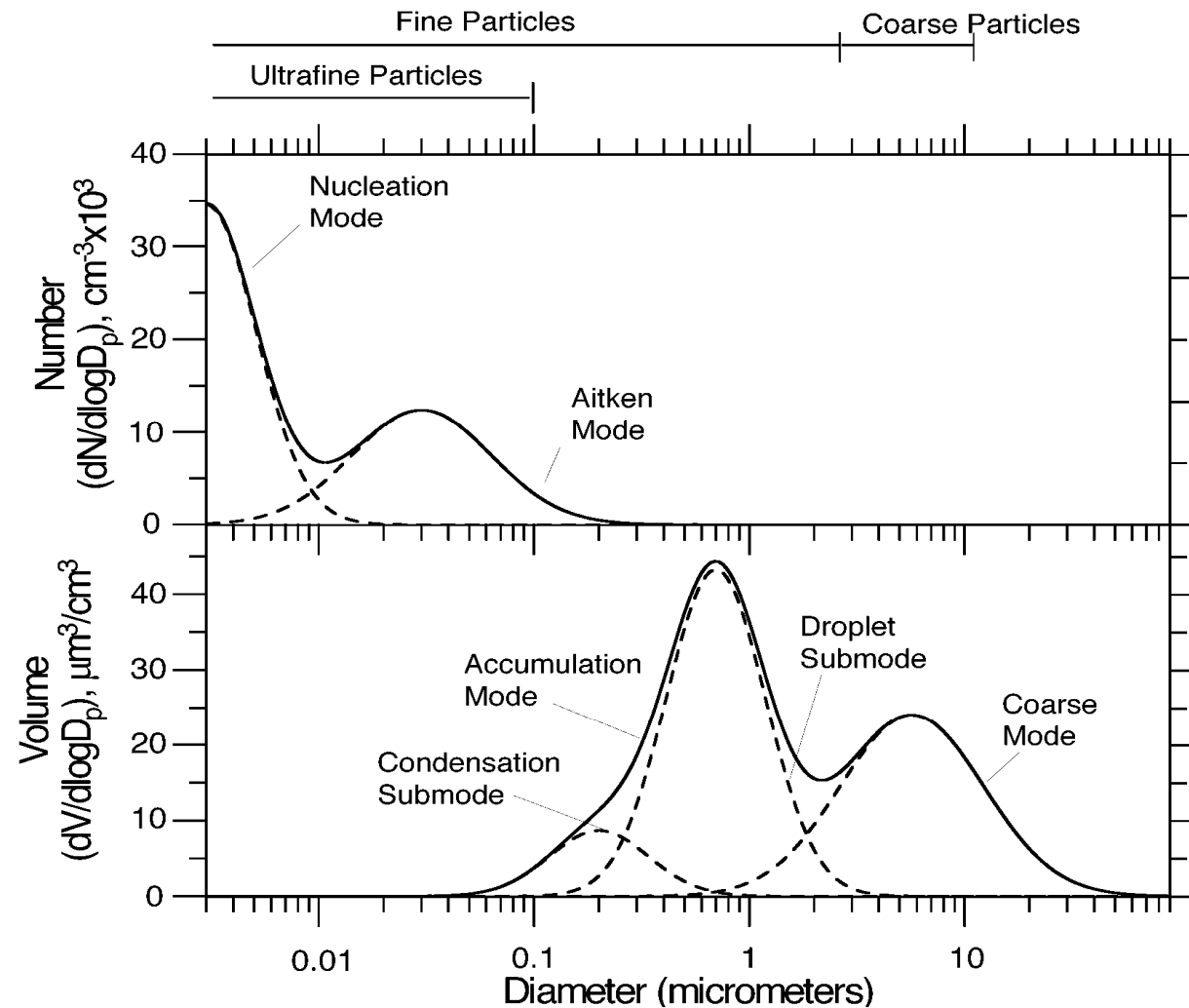
# Effects of Air Pollution and Microclimates on Public Health in Megacities

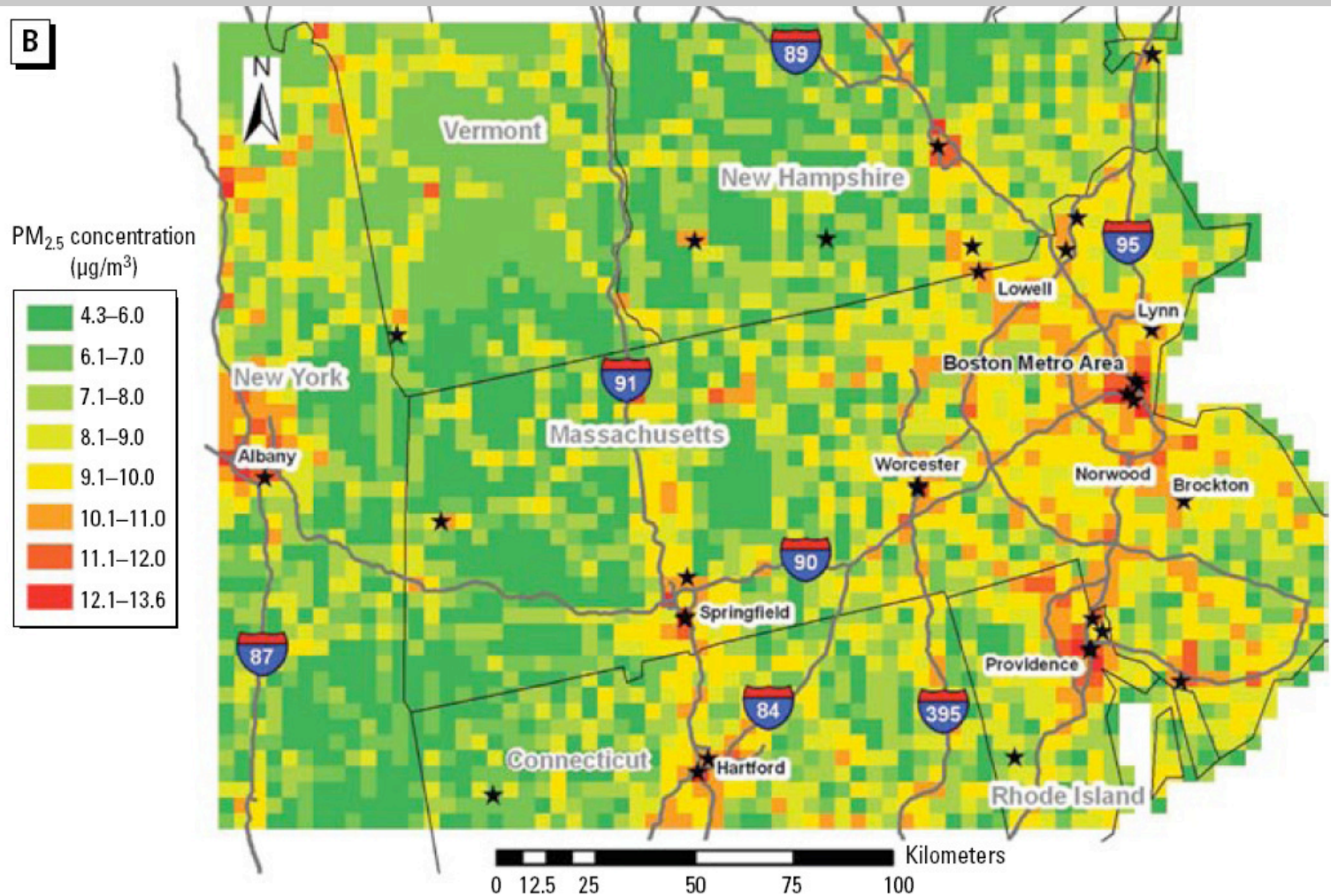
- Fine particulate matter (PM) and other pollutants are associated with premature mortality and respiratory and cardiovascular disease, resulting in serious impacts to urban public health.



# PM Size Distributions

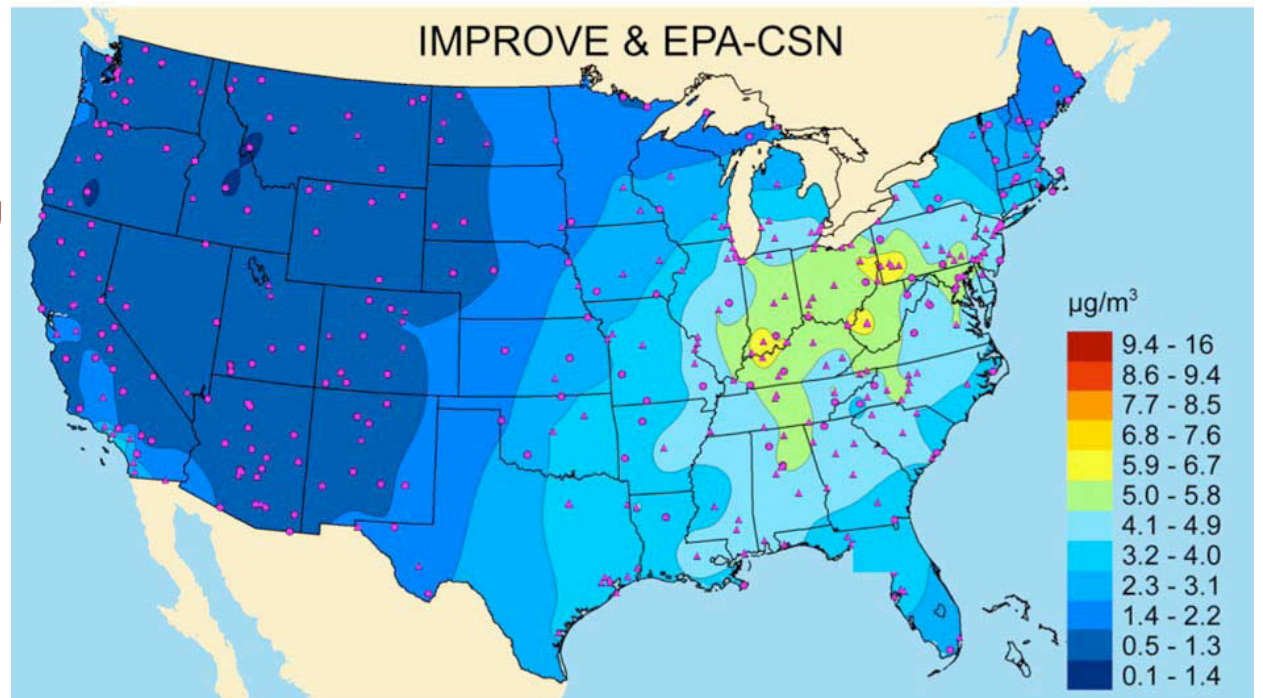
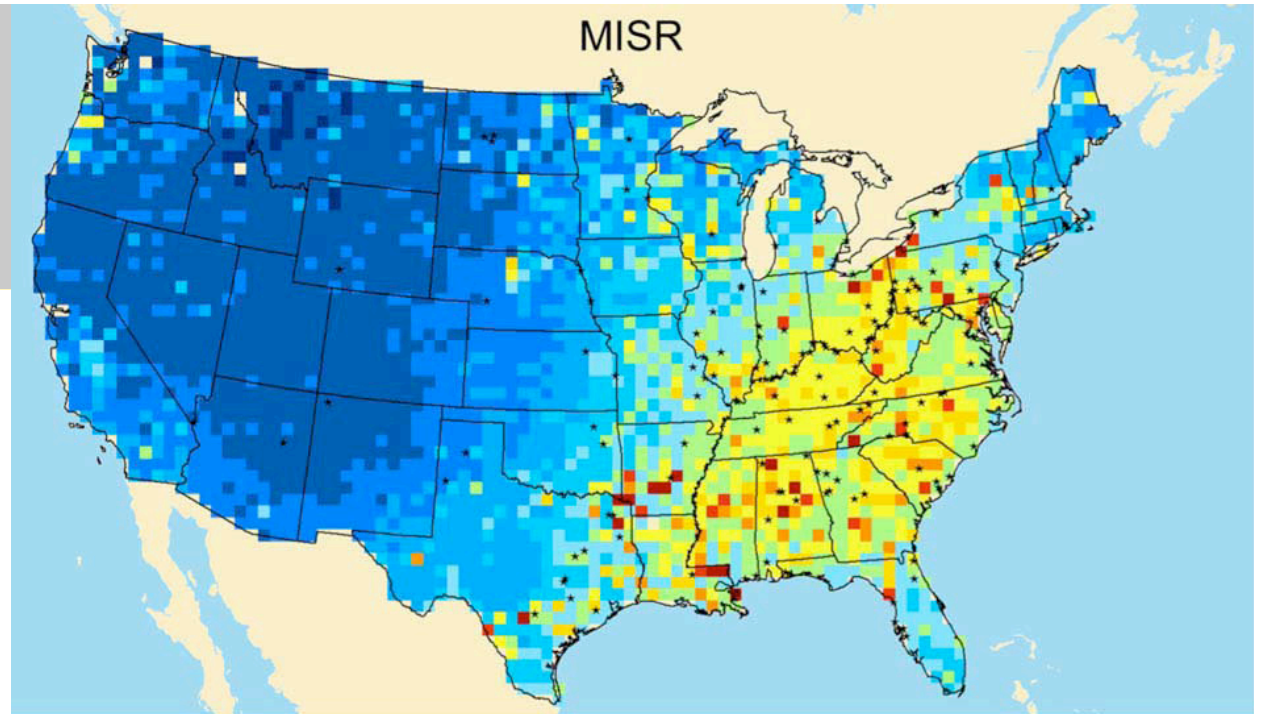
Courtesy of  
C. Sioutas

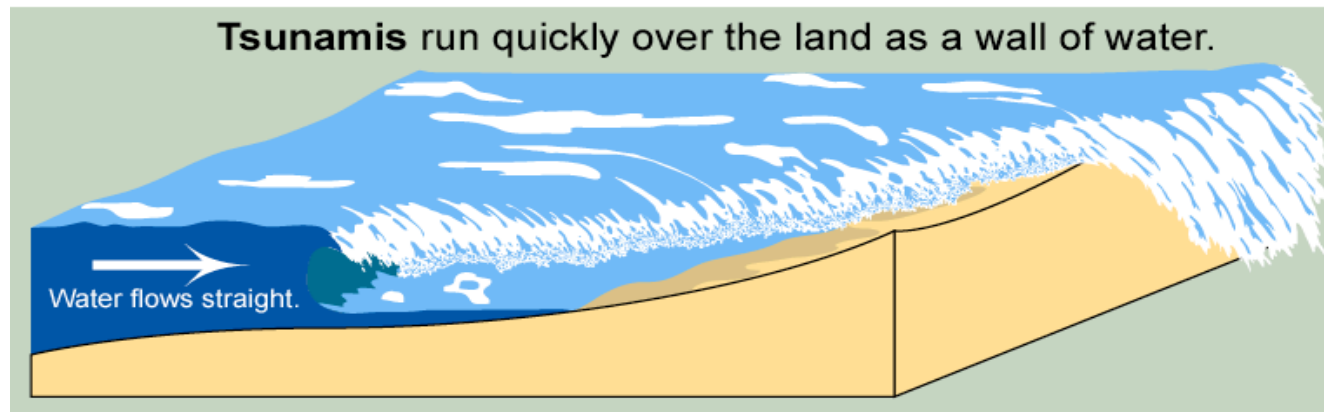
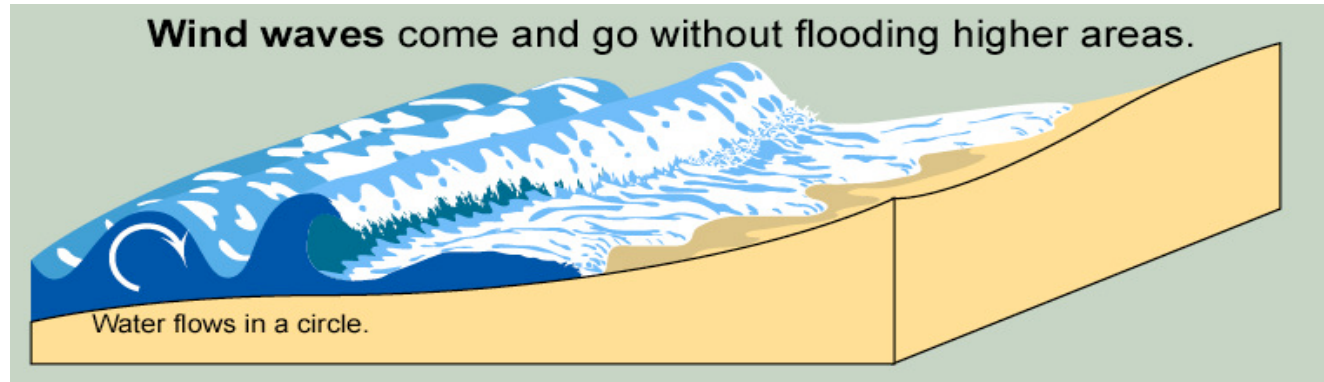




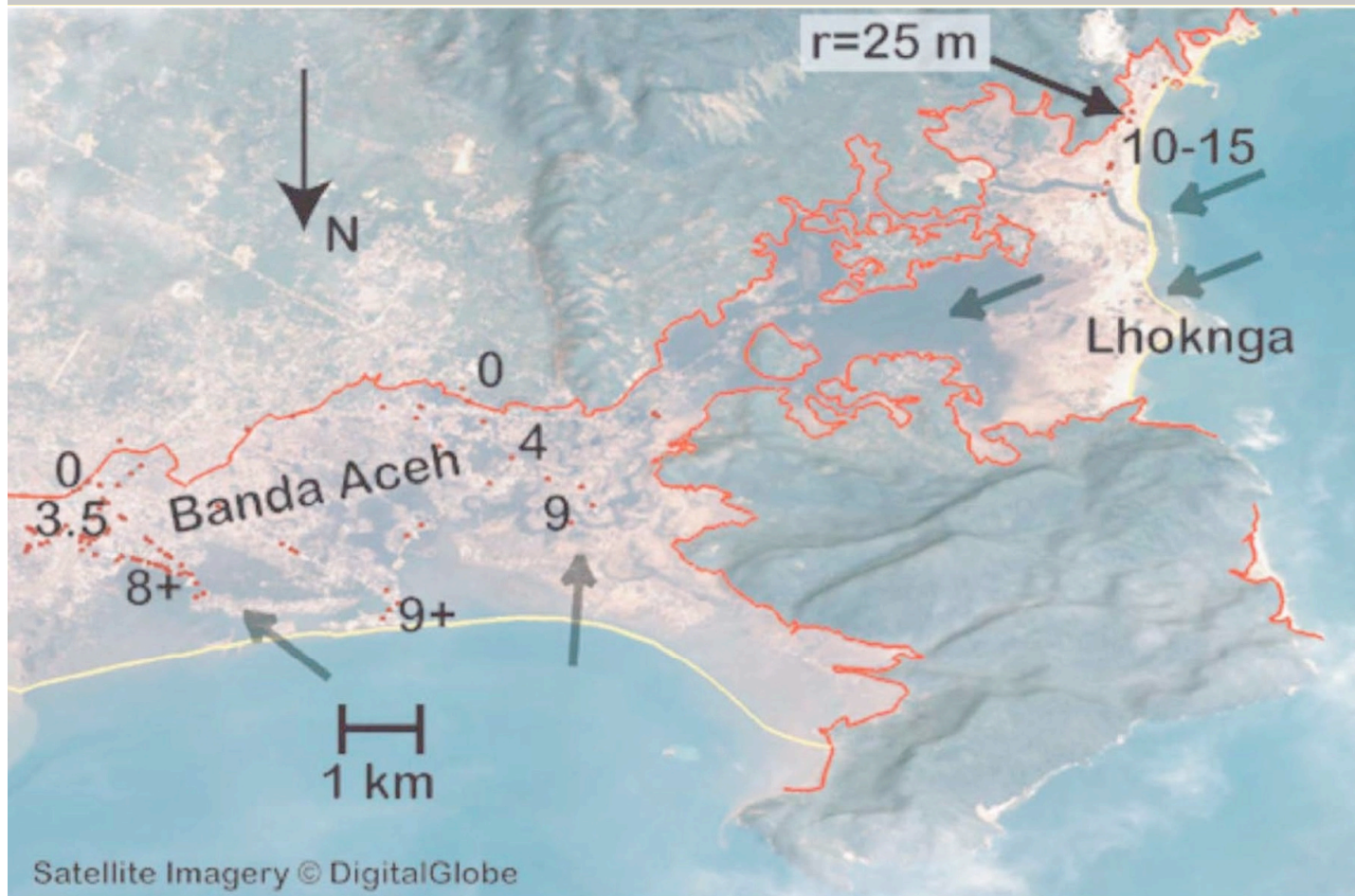
# Air Pollution

Y. Liu, C. J. Paciorek, and P. Koutrakis, 2009, "Estimating Particle Sulfate Concentrations Using MISR Retrieved Aerosol Properties," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing



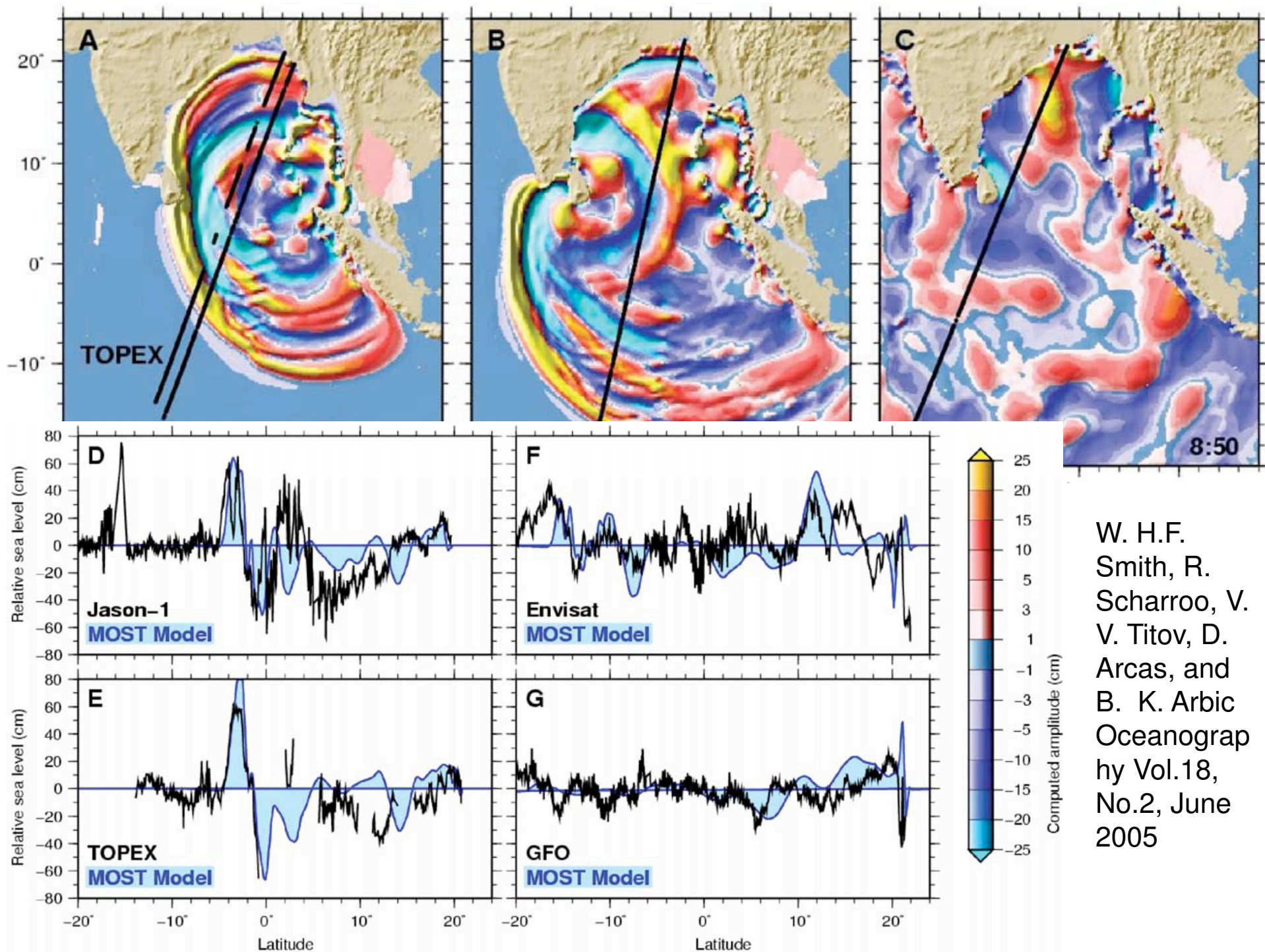


# 2004 Tsunami in Banda Aceh



J. C. Borrero,  
Science, 2005  
Satellite image of  
Banda Aceh after  
tsunami, draped  
over a 500-m DEM.  
Yellow line is the  
shoreline from  
before the tsunami.  
The red line  
identifies the extent  
of inundation.  
Red dots show  
measurement  
locations of flow  
depth or direction.  
Numbers show  
indicative  
measurements.

- RADAR ALTIMETERS on-board the Jason-1, TOPEX, Envisat, and GFO satellites obtained profiles of sea surface height on transects across the Indian Ocean between two and nine hours after the December 26 Sumatra earthquake.
- The data are received hours to days after “real time,” too late to be used in detection and warning of tsunamis.
- Analysis of altimeter data was facilitated by “RADS,” the Radar Altimeter Database System (M. Naeije et al., 2002)



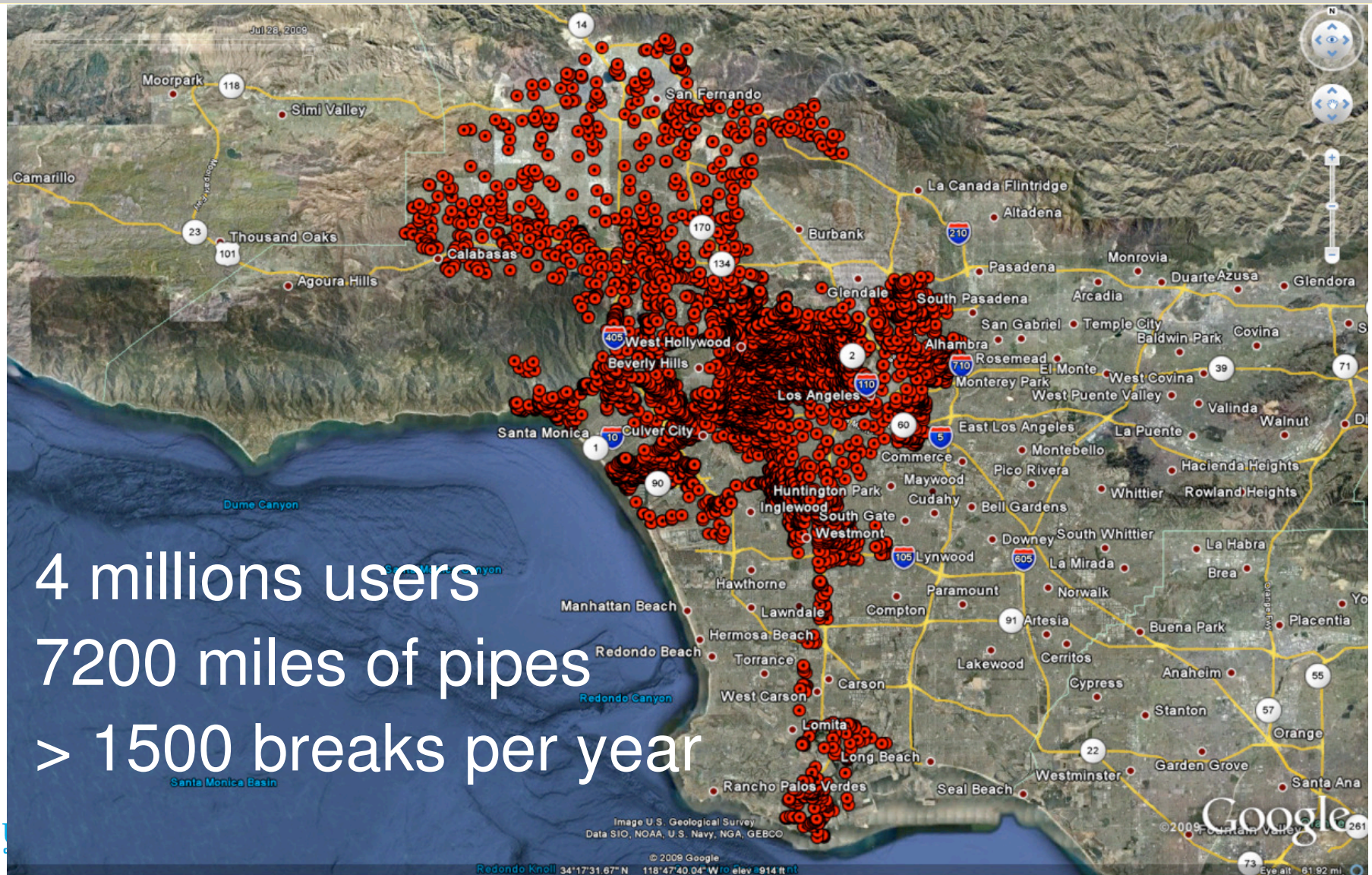
W. H.F.  
 Smith, R.  
 Scharroo, V.  
 V. Titov, D.  
 Arcas, and  
 B. K. Arbic  
 Oceanography Vol.18,  
 No.2, June  
 2005

- Grand Challenges in Engineering
- Civil Engineering and Infrastructure
- Megacities and Urban Infrastructure
- Remote Sensing in Civil Engineering
- **Future Applications**
- Recommendations

CA High Speed Rail  
800 miles  
\$30-80 Billions



# Water Pipe Leaks and Blowouts in LA since 2001



- Civil engineers design, build and operate not only bridges and buildings, but also infrastructures
- ASCE awarded a D grade to our infrastructures
- Civil engineers are familiar with optical imageries, but not as much with SAR and more advanced remote sensing applications
- PSInSAR processing tools need to be more user-friendly and less expensive
- UAVSAR offers a myriad of possibilities for urban infrastructures
- There are many potential applications of remote sensing in civil engineering as we reinvent/rebuild the infrastructure of the 21<sup>st</sup> century